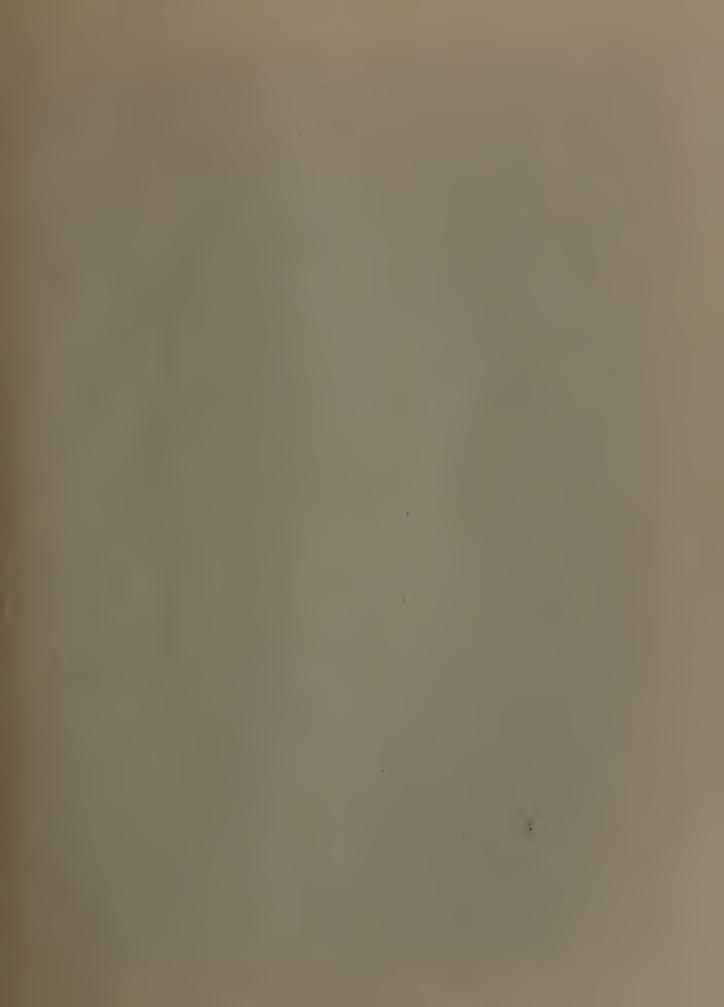
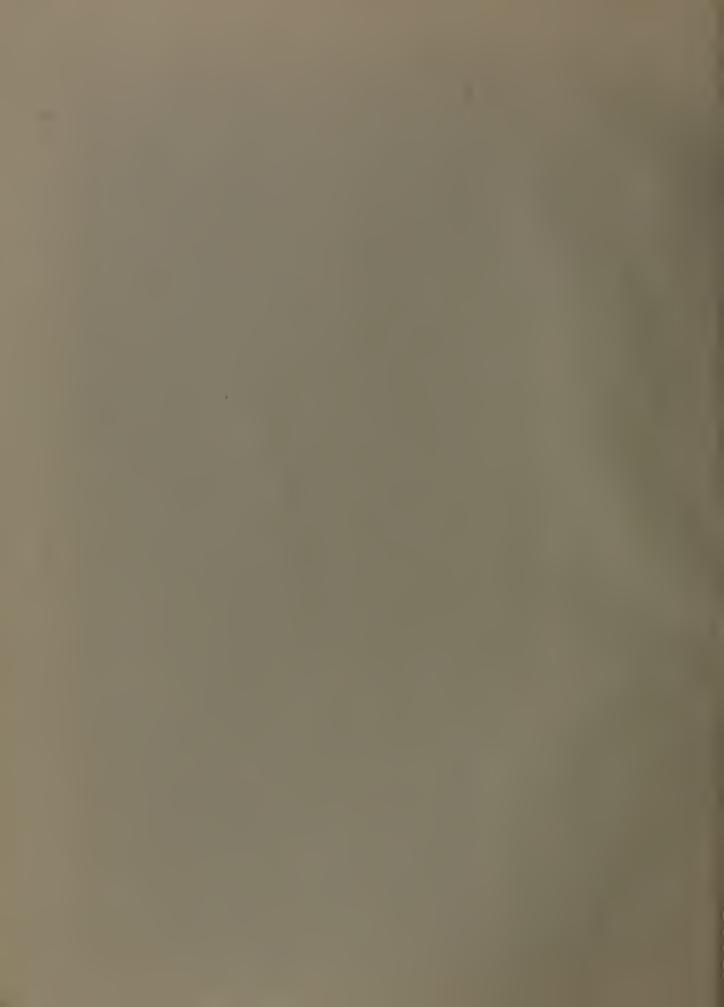


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BULLETIN NO. 72

SAN DIEGUITO RIVER INVESTIGATION



VOLUME I
TEXT AND PLATES

EDMUND G. BROWN Governor



November, 1959

Lake Hodges



HARVEY O. BANKS Director of Water Resources

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STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES

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EDMUND G. BROWN Governor



HARVEY O. BANKS Director of Water Resources

November, 1959





San Dieguita River at the Pacific Ocean north of Del Mar. June, 1951



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State of California Department of Water Resources

SACRAMENTO

April 10, 1959

Honorable Edmund G. Brown, Governor, and Members of the Legislature of the State of California

Honorable Charles C. Dail, Mayor, and Members of the City Council of the City of San Diego

Gentlemen:

I have the honor to transmit herewith Bulletin No. 72, in two volumes, of the State Department of Water Resources, entitled "San Dieguito River Investigation". The investigation and report were financed cooperatively by the City of San Diego and the State of California pursuant to Item 224 of Chapter 1, Statutes of 1956 of the California Legislature.

This bulletin contains preliminary plans and cost estimates for alternative water conservation developments in the San Dieguito River watershed as well as pertinent data on the water resources of the area.

Additional quantities of water from the San Dieguito River could be developed by increased utilization of ground water storage capacity and modification of existing Sutherland and San Vicente storage works. Although the new water yield so obtained would have a minimum unit cost, the quantity would be limited. Larger quantities of new water yield could be developed in the basin at higher unit cost by construction of surface storage reservoirs at either the Pamo "B" site or the San Pasqual site.

The information presented in the bulletin should serve as a guide for maximum practicable development of the water resources of the San Dieguito River.

Very truly yours

HARVEY d. BANKS

Director

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ACKNOWLEDGMENT

Valuable assistance and data used in this investigation were contributed by agencies of the Federal Government, cities, counties, public districts, and by private companies and individuals. The Department of Water Resources gratefully acknowledges this cooperation.

Special mention is made of the helpful cooperation of the City of San Diego Water Department and the following:

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Pacific Telephone and Telegraph Company
Poway Municipal Water District
Ramona Irrigation District
Ramona Municipal Water District
Rincon del Diablo Municipal Water District
San Diego Gas and Electric Company
San Diego State College
San Dieguito Irrigation District
Santa Fe Irrigation District
United States Forest Service
United States Geological Survey, Surface Water Branch

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CHAPTER I. INTRODUCTION

The San Dieguito River, located in the central portion of San Diego County and draining into the Pacific Ocean, has been regulated, and its water utilized, to a limited extent. Only about one-quarter of the natural mean seasonal runoff has been developed by surface diversions, ground water extractions, and two surface storage reservoirs on the stream system. As a result, the balance of the undeveloped and unused water supply of the San Dieguito River presently wastes to the ocean.

This situation exists in spite of the fact that the San Dieguito River watershed and adjacent areas in San Diego County, including the metropolitan area of the City of San Diego, are greatly deficient in local water supplies and are already largely dependent on importation of Colorado River water through the San Diego Aqueduct for satisfaction of their water requirements. This dependency on imported supplies has been increased by the severe drought which San Diego County has experienced since the 1943-44 season. The Second San Diego Aqueduct, which will more than double the capacity to import water to San Diego County, is presently under construction. However, it is estimated that the proportionate entitlement of the City of San Diego to imported water will decrease in the future as the population and the assessed valuation of the San Diego County Water Authority as a whole continues to increase.

As long as imported water supplies are available in sufficient quantity and at a cost less than the cost of further conservation and development of the unused waters of the San Dieguito River, construction of such facilities may be expected to be held in abeyance. However, The California Water Plan contemplates, and the City of San Diego plans, that these local

water resources will be developed some time in the future and put to beneficial use. With this in view, the need for effective long range-planning indicated that a comprehensive investigation should be undertaken and preliminary plans prepared to evaluate prospective conservation projects and to determine the location and size of the most feasible development required to accomplish the further extension of water resources development in the San Dieguito River watershed.

Authorization for Investigation

In 1955, the City of San Diego requested the State Water Resources
Board to conduct a comprehensive investigation of possible water supply
developments in the San Dieguito River watershed. In accordance with the
authority contained in Section 12617 of the Water Code, the State Water Resources Board requested the State Division of Water Resources to undertake
the investigation and prepare a report thereon. The State Water Resources
Board, now designated the California Water Commission, was made a part of the
State Department of Water Resources when that Department was created by
Chapter 52, Statutes of 1956.

The City of San Diego, the State Water Resources Board, and the State Department of Public Works, Division of Water Resources, entered into an agreement, dated July 1, 1956, which provided funds in the amount of \$50,000 for the investigation and authorized the State Division of Water Resources to conduct the studies and prepare a report thereon. The Budget Acts of 1956 and 1957 each provided State funds in the amount of \$12,500. The report was to be completed by June 30, 1958, or as soon thereafter as possible, and funds

for the investigation were to be provided by the City of San Diego and the State of California on a matching basis. Early in 1958 it became apparent that available funds were insufficient to complete the investigation and report. A supplemental agreement was therefore executed by the City and the Department on June 30, 1958, providing for the use of additional funds from the State Budget Act of 1958 and the City in the amount of \$9,000 from each party, amounting to a total of \$68,000 for the entire investigation. The basic agreement and the amendment thereto appear in Appendix A of this report.

Related Investigations and Reports

In 1945, at the request of the City of San Diego and after enactment of Chapter 62, Statutes of 1943, and Item 275, Budget Act of 1945, by the State Legislature, the former Division of Water Resources initiated a comprehensive investigation of water supply, water utilization, and flood control development in the San Dieguito River watershed. Results of the investigation were published in 1949, in Division of Water Resources Bulletin No. 55, entitled "San Dieguito and San Diego Rivers Investigation".

Based on the results of that investigation, the following recom-

- "1. That Sutherland Dam be completed substantially as originally designed to provide a reservoir with storage capacity of 36,700 acre-feet, and that a gravity conduit be constructed to transmit water yield to San Vicente Reservoir, the project to be undertaken as soon as is practicable.
- M2. That an enlarged Hodges Dam, to provide a reservoir with the estimated 310,000 acre-feet of storage capacity required in conjunction with Sutherland Reservoir for complete conservation development of surface runoff in San Dieguito Basin, together with necessary pumping plant and conduit to transmit water yield to the City of San Diego, be constructed approximately ten years in advance of anticipated need for supplementary yield therefrom.
- *3. That a program be initiated as soon as is practicable for acquisition of lands, easements and rights of way necessary for construction of an enlarged Lake Hodges with storage capacity of 310,000 acre-feet.

- m4. That a system of pumping wells and collecting pipe line in San Pasqual Valley, of sufficient capacity to lower the water table and effect salvage from natural consumptive use, be constructed when growing water demands of the City of San Diego indicate a need for such supplementary yield.
- m5. That Federal assistance be sought in construction of an enlarged Hodges dam and conservation reservoir, on the basis and to the extent of resultant reduction in downstream flood damages.
- **16. That Mission Gorge Dam No. 2, to provide a reservoir with storage capacity of 29,200 acre-feet as required for complete conservation development of surface runoff in San Diego River Basin, be constructed when growing water demands of the City of San Diego indicate a need for such supplementary yield."

Other reports containing valuable information and data utilized by the Department of Water Resources in connection with the current study are:

- California State Department of Public Works, Division of Water Resources.

 San Diego County Investigation. Bulletin No. 48. 1935.
- California State Department of Public Works, Division of Water Resources.

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 Records and Coefficients 1881 to 1946. Bulletin No. 54. 1947.
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- California State Department of Water Resources, Division of Resources Planning.
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Scope of Investigation and Report

The scope of the investigation was set forth in the Agreement, which is quoted, in part, as follows:

"The work to be performed under this agreement shall consist of (1) re-evaluation of plans for development of the San Dieguito River as presented in Bulletin No. 55, 'San Dieguito and San Diego Rivers Investigation', Division of Water Resources, 1949, (2) investigation of the proposed development on the basis of the reservoirs being operated independently of each other, and also on the basis of coordinated operation with other developments currently supplying water to the City of San Diego, and such other developments as may be contemplated for the future,

(3) investigation of combined operation of various surface storage developments and utilization of the ground water storage capacity in San Pasqual Valley with consideration of water rights which would be affected thereby, (4) preliminary design and estimates of costs of proposed works, (5) determination of the cost of acquisition of lands and rights of way required for proposed works, and (6) economic comparisons of alternative plans for water development."

In originally establishing the scope of the investigation, it was assumed that much of the data compiled during previous investigations, and the results of analysis of these data, would form the bases for the current report. Although this was done to the extent applicable, it was found that the current drought period is critical with respect to safe yield operations for reservoirs in San Diego County and that the drought period from 1895-96 through 1904-05, used in studies for Bulletin No. 55, was of lesser severity. Consequently, it was necessary to estimate monthly values of runoff, precipitation, and evaporation at existing dams and at dam sites under consideration for operation studies covering the current drought period.

No attempt will be made to repeat previously published data in this report, except where a need for continuity exists. A detailed description of historic development in the watershed prior to 1949 and topography of the area is contained in Bulletin No. 55 and is not included herein.

The investigation was initiated in August, 1956, with the establishment of a field office in the City of Escondido. The initial work consisted of the collection of precipitation, runoff, and evaporation records and information pertaining to water imports and exports.

Locations of approximately 750 wells were determined in the field, and monthly and semiannual programs for measuring depths to ground water were established. In addition, six automatic water level recorders were installed in selected wells to record ground water level fluctuations.

In 1956, lands in the watershed were classified as to their capabilities for use under ultimate conditions of development. Land use surveys were conducted in December, 1956, and January, 1957, to determine actual uses of the lands at that time.

Samples of surface and ground waters were collected and analyzed to determine the native quality and to study the nature, cause, and extent of possible quality deterioration, particularly in the coastal portions of the watershed.

Geologic features within the watershed were mapped, primarily as they affected the occurrence and movement of ground water and the feasibility of sites selected for dams under consideration. Subsurface exploration by drilling was accomplished at one dam site, where information on subsurface conditions was not available. The occurrence and availability of ground water in San Pasqual Basin, under various conditions of overlying use and upstream development, were studied in considerable detail.

Mean seasonal runoffs and flood discharges, at existing dams and at dam sites under consideration, were estimated in order to develop plans for additional conservation of local surface water within the San Dieguito River watershed. Plans, including preparation of preliminary designs and cost estimates, were prepared for three different sizes of dams at each of three sites considered and for conveyance facilities to connect with the distribution systems of the City of San Diego which are located outside the watershed. Yields of reservoirs, on the basis of a combined safe yield operation, were determined by use of machine computing techniques.

A substantial portion of the data presented in this report was compiled as part of the Department of Water Resources' continuing basic data collection program. No funds provided by the cooperative contract between the City of San Diego and the State of California were used for this purpose.

The procedures followed in the investigation and the resulting proposed plans and accomplishments are presented in the six following chapters. Chapter II, "Water Supply", presents data on recorded and estimated precipitation, runoff, and the water imports to and exports from the area. A discussion of ground water hydrology, the quality of surface and ground waters, and estimates of safe yields of presently developed water supplies are also given in this chapter.

Chapter III, "Water Utilization and Requirements", describes the past, present, and probable ultimate land use. The unit values of consumptive use of water and present and probable ultimate water requirements within the watershed, and of the City of San Diego, are also given, as are present and probable ultimate supplemental water requirements.

Chapter IV, "Plans for Water Development", presents plans for development of surface and ground water supplies and describes the facilities required to implement the plans.

Chapter V, "Flood Control", discusses flood control accomplishments from operation of large conservation reservoirs.

Chapter VI, "Comparison of Plans for Water Development", compares
the costs and yields of the various plans discussed in Chapter IV.

Chapter VII, "Conclusions and Recommendations", contains conclusions resulting from the investigation and presents recommendations. Plates, which augment the text material and illustrate salient features of plans for water supply development, are found following Chapter VII.

Appendixes to this report contain the agreement authorizing the investigation, a description of the geology of the watershed, previously unpublished precipitation and evaporation records, information on recorded and estimated runoff, water quality mineral analyses, a list of applications to appropriate water, estimates of land use, land classification, consumptive use of water, records and estimates of water import and export, results of exploratory drilling and of laboratory tests of soil samples from potential borrow areas and dam sites under investigation, detailed cost estimates of project works discussed in the report, and results of reservoir operation studies for facilities located, for the most part, outside the watershed.

Detailed data and computations, too voluminous for publication, are available in the files of the Southern California District Office of the State Department of Water Resources.

Area of Investigation

The San Dieguito River watershed includes an area of 345 square miles. It is located in central San Diego County, as shown on Plate 1. The watershed is bordered on the north by the Escondido Creek and San Luis Rey River drainage areas, on the south by Los Penasquitos Creek and San Diego River drainage areas, on the west by the Pacific Ocean, and on the east by the drainage divide between the South Coastal and Colorado Desert Areas.

The watershed consists predominantly of hilly and mountainous areas and rises to a maximum elevation of over 5,700 feet above sea level at its eastern boundary. About 17 square miles of the watershed are valley lands, of which Santa Maria, San Pasqual, and San Dieguito Valleys are the largest in area.

The mean seasonal depth of precipitation in the San Dieguito River watershed varies from a minimum of about 10 inches near the ocean to over 32 inches in the vicinity of Volcan Mountain at the eastern edge of the watershed. The mean seasonal depth of precipitation for the entire watershed, for the 50-year period 1891-92 through 1940-41, was 19.86 inches.

San Dieguito River has an estimated mean seasonal natural runoff, at its mouth, of 43,400 acre-feet. The river extends southwesterly from the confluence of Santa Ysabel and Santa Maria Creeks, southeast of the City of Escondido, and discharges to the Pacific Ocean about one mile north of the community of Del Mar and approximately 20 miles north of the downtown portion of the City of San Diego. Guejito, Black Canyon, and Temescal Creeks, draining the north-eastern sector of the watershed, are the main tributaries of Santa Ysabel Creek. Santa Maria Creek and its tributaries drain the southeastern portion of the watershed. Runoff in the watershed is partially controlled by Sutherland Dam on Santa Ysabel Creek, northeast of Ramona, and Hodges Dam on the San Dieguito River, southwest of the City of Escondido. These facilities are owned and operated by the City of San Diego.

The San Dieguito River watershed contains numerous alluvial ground water basins, of which San Pasqual Basin is the most productive underground reservoir. Many wells for local use are drilled into the decomposed granitic deposits found in the hilly areas.

Although land use in the area of investigation is principally agricultural in nature, there has been a noticeable increase in urban development in the vicinity of the City of Escondido and along the coast at Del Mar in recent years. A special census of the City of Escondido in 1957 found the population to be 10,050 persons, as compared to a population of 6,544 in 1950.

Irrigation districts have operated in the watershed since 1927 and, more recently, several municipal water districts have been organized, primarily to receive and distribute imported Colorado River water to service areas within the watershed.

To aid in the analysis of the water problems and the evaluation of water resources and requirements within San Dieguito River watershed, the area was divided into three hydrologic units, "Inland Unit", "Central Unit", and "Coastal Unit", and seven hydrologic subunits. These are shown on Plate 1 and described in Table 1. Location of streams, existing dams and reservoirs, cities, major water service agencies, and principal roads are also shown on Plate 1.

TABLE 1

DESCRIPTION OF HYDROLOGIC UNITS AND SUBUNITS OF SAN DIEGUITO RIVER WATERSHED

Hydrologic unit :	Description	: Area	1,
and subunit	Description	: square	miles
Inland Unit			
Sutherland Subunit	Drainage area above Sutherland Dam	54.0	
Pamo Subunit	Drainage area between Sutherland Dam and U.S.G.S. gaging station on Santa Ysabel Creek near Ramona (Pamo)	57•5	
Ramona Subunit	Drainage area above U.S.G.S. gaging station on Santa Maria Creek near Ramona	57.0	
Guejito Subunit	Drainage area above U.S.G.S. gaging station on Guejito Creek near San Pasqual	22.4	
Roden Subunit	Drainage area between U.S.G.S. gaging stations on Santa Ysabel Creek near Ramona and near San Pasqual	16.6	
Subtotal			207.5
Central Unit			
San Pasqual Subunit	Drainage area between Inland- Central Unit boundary and above U.S.G.S. gaging station on San Dieguito River near San Pasqual	41.2	
Hodges Subunit	Drainage area between U.S.G.S. gaging station on San Dieguito River near San Pasqual and Hodges Dam	53.2	
Subtotal			94.4
Coastal Unit	Drainage area below Hodges Dam	43.0	
Subtotal			43.0
TOTAL			314.9

CHAPTER II. WATER SUPPLY

The principal source of water supply in San Dieguito River watershed is direct precipitation, occurring almost entirely in the form of rainfall. Imported Colorado River and San Luis Rey River water serves as a supplemental water supply in the Escondido area. Colorado River water also satisfies a portion of the water requirements within the watershed west and southeast of Lake Hodges.

The magnitude of precipitation and resulting stream flow varies erratically over a wide range. Ground water is utilized extensively throughout the watershed both in the valley and hill areas.

Precipitation

Bulletin No. 55 described 40 precipitation stations and presented value of estimated mean seasonal depths of precipitation at 31 stations in or near the San Dieguito River watershed. The type and occurrence of storms and the characteristics of precipitation in the watershed were also discussed in that bulletin. Precipitation studies undertaken during this investigation were limited to collection and compilation of records of precipitation at Hodges Dam, San Pasqual Valley, Sutherland Dam, and Escondido stations.

Precipitation records at Hodges Dam, San Pasqual Valley, and Sutherland Dam stations were used in surface reservoir yield studies. Records of precipitation at the San Pasqual Valley station were also utilized in studies of the operation of San Pasqual ground water basin. Records and estimates of monthly precipitation for these three stations for the period 1936-37 through 1956-57 appear in Appendix C to this report.

Long-time mean seasonal precipitation data included in Bulletin No. 55 were used to determine the portion of the present and probable ultimate water requirements within the watershed which could be satisfied by precipitation. The estimated mean seasonal depth of precipitation over the entire watershed is 19.86 inches and varies from less than 10 inches at the coast to over 32 inches in the vicinity of Volcan Mountain. Estimated mean seasonal depth and total quantity of precipitation for the hydrologic units and subunits for the 50-year period, 1891-92 through 1940-41, are presented in Table 3. Lines of equal mean seasonal precipitation and location of selected precipitation stations in or near the watershed are shown on Plate 2. The station numbering shown on Plate 2 is that used in Bulletins No. 48 and 55.

During the 82-year period, from 1875-76 through 1956-57, seasonal precipitation at the United States Weather Bureau station at Escondido has varied widely, ranging from an estimated maximum of 39.77 inches in 1883-84 to a minimum of 5.96 inches in 1893-94. From 1944-45 through 1956-57, above-normal seasonal precipitation occurred only in the 1951-52 season, resulting in a precipitation deficiency of about 51 inches for the 13-year drought period. Recorded and adjusted seasonal precipitation at Escondido for the period 1875-76 through 1956-57, and the accumulated departure from mean seasonal precipitation at this station for the same period, are shown on Plate 3.

Runoff

San Dieguito River is an intermittent stream, although it frequently flows for protracted periods. Effluent from San Pasqual ground water basin resulted in intermittent flow in the San Dieguito River above Lake Hodges until 1954, when seepage ceased due to declining ground water levels. Santa Ysabel, Santa Maria, Guejito, Black Canyon, and Temescal Creeks are also intermittent streams throughout most of their length.

The earliest measurements of runoff in the San Dieguito River watershed were made in 1906. Records of stream flow for Santa Ysabel Creek at Sutherland Dam and at Pamo dam site, located approximately four and one-half miles north of Ramona, commenced in 1912, while records of flow in the San Dieguito River at Hodges Dam started in 1916. United States Geological Survey and privately-operated stream gaging stations, currently or historically located in the watershed, are described in Table 2. Locations of these stations are shown on Plate 2. The station numbers shown on Plate 2 are those used in Bulletins No. 48 and 55. In consideration of the length of runoff records and the number of active stream gaging stations, no additional stations were installed by the State Department of Water Resources for purposes of this investigation.

TABLE 2

STREAM CACING STATIONS IN SAN DIEGUITO RIVER WATERSHED

Plate 2	480	••	Logation		Bres, in:					Source
station number	: Stream and station	Section	: Town : R	Range	square:		Perio	Period of resord	pac	30 :
99	Santa Yashal Grask, ness Santa Yashal	36	125.	(E)	23	Ano. 1	1913 1	through Se	Sept. 1914	1 S. 6. S. 8
9 00	Carto Vaskal Casak at Suchaaland	3 6	125.	OE.	}-ਰੋ					TI.S. C.S.
7	Santa Yashel Greek, near Mass. Grande	17 & 20	125.	2E.	. z.				Sept. 1936	E Green
				,	`				Sept. 1953	U.S.G.S.
230	Santa Yaabel Creek, near Mesa Grands	17 & 20	12S.	2E.	55				Present	U.S.G.S.
23A	Santa Yaabel Creek, at Sutherland Dam		125.	25.	法				208ea	U.S.G.S.
34,	Black Canyon Creek, near Mess Grande	127	125.	2E.	F-1	Feb. 1		through Se	Sopt. 1924	U.S.G.S.
25	Tenesoal Creek, near Almend	23	32S.	E	32	Fob. 1		through Se	Sept. 1915	U.S.G.S.
32,	Santa Yeabel Creek, near Ramons	27	125,	Œ,	133	Feb. 1	1912 क्ष	through Fe	Feb. 1923	U.S.G.S.
	Santa Yaabel Creek, at Pamo	12	125.	E	113	00%. 1		through Present	resent	U.S.G.S.
27	Santa Yasbel Creek, near Escondido	3	125.	JE.	128	Des. 1	905 th	through S	Sept. 1912,	U.S.B.S.
27A	Santa Tsabel Creek, near San Pasqual	33	125.	3E.	128	Apr. 1	1947 to	through Sept.	Pp. 2956	U.S.G.S.
	,					Septe	1956	1956 through Present	Present	U.S.G.S.
28	East San Pasqual Ditch, near Escendide	×	125.	3W.	000	June 1	912 1	1912 through Sept.		U.S.G.S.
29	Guelito Creek, near Escondido	35	125.	JW.	28	Feb. 1	1915 th	through Sept.		U.S.G.S.
	Guejite Creek, at San Basqual	35	125.	JW.	28	0ct. 1		through Sept.		U.S.G.S.
						06to 1	1919 41	through Sept.	pp. 1924	F. E. Green
						0at. 1		through S.	Sept. 1922	V.L. &W.Co.
								through S	Sept. 1956	U.S.G.S.
29A	Guejite Creek, near San Pasqual	23	125.	36	5 pt	Dec. 1	138 1	through Present	resent	U.S.G.S.
30	West San Pasqual Ditch, near Escondido	ま	125.	JW.	900	Mey 19	12 th	rough Se	1912 through Sept. 1915	U.S.G.S.
3	Santa Maria Creek, near Ramona	11	135.	14.	22	0ot. 1	912 ti	hrough S	ept. 1924	F. E. Green
								through S	Sept. 1920	U.S.G.S.
							1919 4	through Se	Sept. 1923	V.L. &W.Co.
									Present	U.S.G.S.
32	San Dieguito River, at Bernardo	11	135.	2W.	270	Apr. 1		through Je	Jan. 1916	U.S.G.S.
324	San Dieguito River, near San Pasqual	H	138.	2М.	250	Apr. 1		through S	Sept. 1956"	U.S.G.S.
						Oot. 1		through Present	resent	U.S.G.S.
33	San Dieguito River, at Lake Hodges	18	135.	2W.	303	Jan. 1	1916 ti	through Present	resent	U.S.G.S.
334	San Dieguito River, downstream from Lake Hodges	†	138.	3₩.	310	Septe	1953	1953 through Present	Present	U.S.G.S.
34	San Diemite River, near Del Mar	35	138°	34.	327	Oot. 1	912 t	hrough S	1912 through Sept. 1914	U.S.G.S.

United States Geological Survey.
Private records of F. E. Green, hydrographer for City of San Diego.
Used for measuring spill from reservoirs.
Irrigation season only.
Volcan Land and Water Company.

Recorded and estimated values of monthly runoff from selected areas in San Dieguito River watershed for the period from 1914-15 through 1956-57 are contained in Appendix D.

Mean seasonal natural runoff in San Dieguito River watershed during the 43-year period, 1914-15 through 1956-57, closely approached the long-time mean seasonal natural runoff for the 53-year period 1894-95 through 1946-47, used in State Water Resources Board Bulletin No. 1. The mean values of runoff used in the current study are those for the period from 1914-15 through 1956-57.

Estimated mean seasonal natural runoff of the San Dieguito River, at its mouth, is 43,400 acre-feet, and at Hodges Dam is 41,200 acre-feet. Santa Ysabel Creek, the most productive tributary, has an estimated mean seasonal natural runoff, at Sutherland Dam, of 14,000 acre-feet. Estimated mean seasonal depth and total quantity of both precipitation and runoff, in hydrologic units and subunits, within the San Dieguito River watershed are presented in Table 3. Plate 2 illustrates diagrammatically the mean seasonal natural runoff of the San Dieguito River and its major tributaries.

TABLE 3

ESTIMATED MEAN SEASONAL PRECIPITATION AND NATURAL RUNOFF IN SAN DIEGUITO RIVER WATERSHED

Hydrologic unit		easonal itation		easonal l runoff	: Runoff, in
and subunit	: Depth, : in inches:	Acre-feet	: Depth, : :in inches:	Acre-feet	: per cent of :precipitatio
Inland Unit					410
Sutherland Subunit	27.92	80,400	4.86	14,000	17.4
Pamo Subunit	24.41	74,900	3.10	9,500	12.7
Ramona Subunit	19.66	59,700	1.70	5,200	8.6
Guejito Subunit	20.85	24,900	2.51	3,000	12.0
Roden Subunit	17.36	15,400	2.60	2,300	15.0
Subtotals		255,300		34,000	
Averages	23.08		3.07		13.3
Central Unit					
San Pasqual Subunit	16.44	36,200	1.41	3,100	8.6
Hodges Subunit	15.98	45,400	1.44	4,100	9.0
Subtotals		81,600		7,200	
Averages	16.19		1.43		8.8
Coastal Unit	12.42	28,500	0.96	2,200	7.7
TOTALS		365,400		43,400	
AVERAGES	19.86		2.36		11.9

The quantity of runoff from the San Dieguito River watershed has fluctuated erratically from year to year in a manner similar to precipitation. Since December, 1912, recorded seasonal runoff of Santa Ysabel Creek at Sutherland Dam has varied from a minimum of 610 acre-feet in 1954-55, to a maximum of 95,200

acre-feet in 1915-16. In 1915-16 the estimated runoff of the San Dieguito River at Hodges Dam was 775 per cent of the seasonal mean.

Commencing in 1943-44, the San Dieguito River watershed has experienced the most severe drought of record, with runoff being below normal in each year except 1951-52. Maximum, minimum, and mean seasonal natural runoff by hydrologic units and subunits within San Dieguito River watershed for the period from 1914-15 through 1956-57 is presented in Table 4.

Recorded and estimated seasonal runoff and the accumulated departure from mean seasonal runoff of the San Dieguito River at Lake Hodges for the period 1887-88 through 1956-57 is illustrated on Plate 3.

TABLE 4

RECORDED AND ESTIMATED MAXIMUM, MINIMUM, AND MEAN SEASONAL NATURAL RUNOFF IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1914-15 THROUGH 1956-57

-fru

Hydrologic unit	: Maximu		atural runoff Minim	ım	Mean, in
and subunit	: Acre-feet :		: Acre-feet :	Season	acre-feet
Inland Unit					
Sutherland Subunit	95,200	1915-16	610	1954-55	14,000
Pamo Subunit	54,200	1915-16	160	1954-55	9,500
Ramona Subunit	41,500	1915 - 16	0	1920-21 1933-34 1949-50 1950-51 1955-56 1956-57	5,200
Guejito Subunit	25,300	1915-16	120	1956-57	3,000
Roden Subunit	18,000	1915-16	80	1954-55	2,300
Central Unit					
San Pasqual Subuni	t 33,500	1915-16	30	1918-19	3,100
Hodges Subunit	45,600	1915-16	0	1918-19 1949-50 1950-51 1955-56	4,100
Coastal Unit	20,000	1915-16	0	1918-19 1949-50 1950-51 1955-56	2,200

Import and Export of Water

Import

Escondido Irrigation District, predecessor of the Escondido Mutual
Water Company, with a service area lying partly within the San Dieguito River

watershed, first diverted water from the San Luis Rey River in 1895. The quantity imported from this source since the season of 1936-37 has varied between 900 and 4290 acre-feet per season. Recent imports from the San Luis Rey River, as a result of the current drought, have been reduced somewhat and average about 2,400 acre-feet for the past three seasons.

The San Diego County Water Authority, a member agency of The Metropolitan Water District of Southern California, consisted of 17 member agencies on June 30, 1957, representing an area of 434,534 acres, a population of 783,550 persons, and a 1957-58 assessed valuation of \$1,001,006,270. The City of Escondido, Rincon del Diablo Municipal Water District, Poway Municipal Water District, and Santa Fe Irrigation District lie partly within San Diego County Water Authority, are receiving imported Colorado River water from the San Diego Aqueduct.

Escondido Mutual Water Company, although not a member of the San Diego County Water Authority, receives Colorado River water through the facilities of Rincon del Diablo Municipal Water District. All Colorado River water received by Santa Fe Irrigation District is released from the San Diego Aqueduct into the San Dieguito River at a point south of the City of Escondido, flows into Lake Hodges, and is conveyed by flume from Lake Hodges through the San Dieguito Reservoir to the District service area.

In recent years, the afore-mentioned member agencies of the San Diego County Water Authority have purchased more than their entitlement of Colorado River water. Furthermore, the City of San Diego has, in the past, agreed to purchase and store Colorado River water during the winter months in order to permit the delivery of sufficient water from the aqueduct, during summer months, to member agencies having inadequate regulatory storage capacity.

It is anticipated that Ramona Municipal Water District, which joined the Authority in 1957, will soon be purchasing and distributing imported Colorado River water. The proposed Olivehain Municipal Water District and proposed annexations to Ramona, Poway, and Rincon del Diablo Municipal Water Districts and the City of San Diego will further expand the total area of the Authority and the area in the watershed eligible to receive imported Colorado River water.

Estimates of seasonal imports of Colorado River and San Luis

Rey River water to the San Dieguito River watershed are set forth in

Table 5 and Appendix E, which also contains a description of the previously

mentioned water importing agencies. Location of the service areas of

agencies importing water to the watershed is shown on Plate 1.

OF WATER AFFECTING SAN DIEGUITO RIVER WATERSHED ESTIMATED SEASONAL IMPORTS AND EXPORTS

In Acre-Feet

to:		Imports		00	Exports			00	Net imports	lg	tsb
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Colorado: S River : I	San Luis : Rey River: water :	Total	Colorado: River:	San Luis : Rey River: water :	San Dieguito River water	Total	Colorado: River: Water:	San Luis Rey Riven water	San Dieguito River water	
1,9380 0 7,340 7,340 7,340 0 1,380 - 7,340 1,9420 0 0 6,990 6,900 0 1,420 - 6,900 1,960 0 7,630 7,630 0 7,630 0 7,800 2,901 0 7,880 7,880 7,880 0 2,910 7,880 2,901 0 7,880 7,880 7,880 7,880 7,880 2,901 0 7,880 7,880 7,880 7,880 7,880 2,940 0 8,540 8,550 8,550 9,280 7,880 2,380 0 8,550 8,550 8,550 3,800 7,710 12,900 12,700 7,220 7,220 7,290 2,920 7,940 12,910 12,530 1,290 1,290 1,290 1,290 1,200 13,230 7,410 0 7,320 7,320 2,960 2,960 7,320 <td></td> <td>900 1,290 1,450 1,680</td> <td>900 1,290 1,450 1,680</td> <td>0000</td> <td>0000</td> <td>6,420 6,930 7,100 7,110</td> <td>6,420 6,930 7,100 7,110</td> <td>0000</td> <td>900 1,290 1,2450 1,680</td> <td></td> <td>55,520 55,640 55,430</td>		900 1,290 1,450 1,680	900 1,290 1,450 1,680	0000	0000	6,420 6,930 7,100 7,110	6,420 6,930 7,100 7,110	0000	900 1,290 1,2450 1,680		55,520 55,640 55,430
2,530 0 0 8,540 8,540 0 2,530 -8,540 0 2,380 -8,540 0 2,380 0 2,380 -8,540 0 2,380 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		1,380 1,420 1,960 2,010 1,940	1,380 1,420 1,960 2,010 1,940	00000	00000	7,340 6,900 7,630 7,830 7,880	7,340 6,900, 7,630 7,830 7,880	00000	1,380 1,420 1,960 2,010 1,940		2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2
13,230 7,410 0 810 8,220 2,840 2,980 810 8,220 2,7320 30 2,760 7,320 1,2170 0 0 7,320 7,320 30 4,140 9,260 1,2170 0 0 12,760 12,760 90 4,290 1,2760 11,4450 8,390 0 120 8,510 5,630 2,120 17,740 7,4450 0 2,020 9,4470 7,520 2,770 2,302	0 0 7,190 9,240	%%%%% %%%%% 700 700 700 000 000 000 000	2,530 2,380 2,700 12,910 12,500	0 0 0 1,270 7,530	0 0 0 1,920 320	8,540 8,550 7,720 1,100	8,540 8,550 7,720 7,290 8,050	0 0 0 2,920 710	2,30 2,30 3,700 3,800 2,940	8877	6,010 6,170 -5,020 5,620 4,450
16,340 8,590 0 120 8,710 5,630 2,120 120 17,740 7,450 0 2,020 9,470 7,520 2,770 2,020	10,250 30 30 90 12,090	2,980 2,760 4,140 4,290 2,360	13,230 2,790 4,170 14,380 14,450	7,410 0 0 0 8,390	00000		8,220 7,320 9,260 12,760 8,610	α η	2.980 2.760 4.140 4.290 2.360	810 7,320 9,260 -12,760	2, 4, 4, 5, 010 2, 4, 5, 5, 010 3, 3, 8, 1, 5, 010 8, 1, 8, 1, 0
	14,220 14,970	2,120 2,770	16,340 17,740	8,590	00	00	8,710 9,470	5,630	2,120 2,770	ď	7,630

Net export is denoted by a minus sign. or agencies lying within and used outside the watershed. ာ့

Construction of Hodges Dam, San Dieguito Dam, and related structures was completed in 1919, at which time export of water through these facilities from the San Dieguito River watershed commenced. The City of San Diego leased these facilities in 1925, prior to purchase in 1939, for the purpose of securing a supplemental water supply. At that time, the City assumed the obligation to furnish from Lake Hodges to the Santa Fe and San Dieguito Irrigation Districts and the Del Mar Water, Light, and Power Company, now Del Mar Utilities, 6,576 acre-feet, 3,200 acre-feet, and 724 acre-feet of water per year, respectively. In 1945, a further agreement between Santa Fe Irrigation District and City of San Diego reduced the obligation to that District from 6,576 acre-feet per year to 4,300 acre-feet per year, and this agreement is still in effect. During periods of drought, the obligation of the City of San Diego to furnish water to Del Mar Utilities may be reduced by 25 per cent, at the option of the City. Furthermore, in the event Lake Hodges is depleted, the City may fulfill its obligations by furnishing the aforesaid agencies with Colorado River water discharged into Lake Hodges from the San Diego Aqueduct.

Santa Fe and San Dieguito Irrigation Districts and Del Mar Utilities lie wholly or partially outside the San Dieguito River watershed. Therefore, the portion of the afore-mentioned deliveries used outside the watershed constitutes an export. Water exported to the City of San Diego from Lake Hodges passes through San Dieguito Reservoir and is conveyed to the Torrey Pines Filtration and Pumping Plant located about 12 miles south of San Dieguito Reservoir.

In 1954, Sutherland Dam on Santa Ysahel Creek was completed by the City of San Diego, and diversion of water through a conduit from Sutherland Reservoir to San Vicente Reservoir on San Vicente Creek, tributary to the San Diego River, was initiated the same year.

although the San Dieguito Irrigation District, which lies entirely outside the San Dieguito River watershed, and the Santa Fe Irrigation District are member agencies of the San Diego County Water Authority, they are without direct pipe line connections to the San Diego Aqueduct. Through an agreement with the City of San Diego, Colorado River water purchased by the two irrigation districts is released from the aqueduct and passed through Lake Hodges and San Dieguito Reservoir before distribution within the service areas. A portion of the Colorado River water used within the City of San Diego is also released from the aqueduct above Hodges Dam and passes through Lake Hodges and San Dieguito Reservoir to the previously mentioned Torrey Pines Filtration and Pumping Plant. Estimated seasonal exports of local, San Luis Rey River, and Colorado River water from San Dieguito River watershed are presented in Table 5 and Appendix E.

Ground Water Hydrology

Valley areas with a capability for the subsurface storage of water comprise less than 10 per cent of the San Dieguito River watershed. The most productive areas are the alluvium—filled San Pasqual and San Dieguito Basins. Water is also extracted, to some extent, by wells located in less permeable formations underlying hilly areas.

Over 750 wells were visited during the investigation. For these wells, available drillers' logs were collected and information as to pumping plant equipment, diameter and depth of casing, use and age of well, and ownership was recorded. The location of wells is shown on Plate 4.

A program of semiannual measurement of the depth to ground water

in over 400 wells, was established in the fall of 1956 in San Pasqual, San Dieguito, and Ramona Basins. About 74 wells in San Pasqual and San Dieguito Basins were measured on a monthly basis, and six automatic ground water level recorders were installed. Records of monthly measurements of depth to ground water in approximately 64 wells in San Pasqual Basin were secured from the City of San Diego. Ground water samples were collected from selected wells within the watershed and analyzed to determine concentrations of mineral constituents.

Basic data concerning depth to ground water are not presented in this report. Available ground water level data for the fall of 1956 and spring of 1957 for San Dieguito River watershed are published in State Department of Water Resources Bulletin No. 39~57, "Water Supply Conditions in Southern California During 1956-57", dated June, 1958. Records for each year subsequent to the spring of 1957 will be published in succeeding annual reports in the same series. Records of ground water levels prior to the fall of 1956 may be inspected at the Southern California District office of the Department of Water Resources and, after collation and analysis, will be published in a forthcoming annual volume of Bulletin No. 39.

Geologic Considerations

Rocks exposed in the San Dieguito River watershed range in age from Triassic to Recent and may be divided broadly into basement complex and younger sedimentary formations. Basement complex consists of metasediments of Triassic age; intrusive, extrusive, metamorphic, and granitic rocks of Jurassic age; and granitic rocks of Cretaceous age. The sediments, which overlie the basement complex, from the ocean to about 9 miles inland include marine and nonmarine sediments of Eocene age and alluvium of Recent age.

The granitic and metamorphic rock has been weathered in many areas to form up to 100 feet of residuum.

Because of its relatively high permeability and porosity, the alluvium is the principal water-bearing deposit. In some areas, however, the alluvium is thin and lies above the ground water surface. Domestic and limited amounts of irrigation water are secured from wells in the residuum and from deep wells in areas where the granitic bedrock is sufficiently fractured to contain ground water in recoverable amounts. Eccene sediments generally yield only limited quantities of water to wells.

The basement complex is essentially a fault block which has been tilted westward. The Elsinore fault system extends through the eastern end of the watershed. Available evidence indicates that only the Temescal fault near Ramona affects the movement of ground water. Eccene sediments near the coast have been gently folded and contain minor faults, but their effects on ground water are unknown.

Table B-1 of Appendix B, presents the stratigraphic column of the San Dieguito River watershed and shows the general character of the rocks. Areal geology and general water-bearing characteristics of the rocks in the watershed are shown on Plate 5. Geologic sections for San Dieguito Basin are shown on Plate 6-A and sections for Ramona, San Pasqual, and Lake Hodges Basins are presented on Plate 6-B.

Ground Water Basins

Of the 20 ground water basins in San Dieguito River watershed,
San Pasqual, San Dieguito, Ramona, Felicita, and Lake Hodges Basins are the
principal ground water bodies from the standpoint of areal extent, available

storage capacity, and use. These basins are discussed hereinafter in the order of importance. Location of the ground water basins in the watershed and their general water-bearing characteristics are shown on Plate 4, and a description of the basins is contained in Appendix B. Data pertaining to the five principal ground water basins are presented in Table 6.

TABLE 6

GROUND WATER BASIN DATA FOR PRINCIPAL BASINS

aximum 1 yields orted, in lons per minute	250	1,700	800	300	009
: Maximum : well yields : reported, in : gallons per		í			
: Maximum : Approximate : well yields : number of : reported, i ; active : gallons per : wells : minute	200	100	35	150	20
Estimated usable storage oapsity, *	50° 000	37,000	10,000	11,000	8,000
: : Water~bearing : : formations :	Residuum	Alluvium	Alluwium Residuum	Res1duum	Alluvium
Main tributary etreams	Santa Maria Creek Hatfield Greek Goose Greek	Santa Ysabel Greek Santa Maria Greek Guejito Greek Bach Greek	San Dieguito River	Unnamed orseks	San Dieguito River Gonzales Creek Zanja Greek Lusardi Greek
Surface : surface : area, :elevation; in in : aores : feet :	1,400	390	330	680	25
Surface Rreage 1n aores	17,110	3,430	3,350	3,100	3,910
Hydrographio unit and basin	Inland Hydrologic Unit Ramona Basin	Central Hydrologic Unit San Pasqual Basin	Lake Hodges Basin	Felloita Basin Coastal Hydrologic Unit	San Dieguito Basin

Defined as the upper portion of the total storage capacity which may be utilized without so lowering the ground water levele as to cause harmful impairment of the water quality or to imperil the economy of the use of ground water by excessive costs of pumping from the basin or by exclusion of the users from a supply therefrom.

San Pasqual Basin. San Pasqual Basin, located southeast of the City of Escondido, has a surface area of 3,430 acres. It is the most productive ground water basin in San Dieguito River watershed, with an estimated usable storage capacity of about 37,000 acre-feet. The basin fill consists of a maximum of 200 feet of alluvium, bounded and underlain by crystalline rock.

The major recharge to San Pasqual Basin is from the percolation of stream flow in Santa Ysabel Creek, Santa Maria Creek, Guejito Creek, and Bach Creek. The estimated maximum seasonal percolation from runoff in San Pasqual Basin, during the period 1914-15 through 1956-57, occurred in 1948-49 and amounted to approximately 5,800 acre-feet. Maximum monthly percolation during this period occurred in February, 1936, and was estimated to be 2,400 acre-feet.

Discharge from the basin occurs as subsurface outflow, as effluent flow at the lower end of the basin during years of high ground water levels, and as pumping from approximately 100 active wells. Many wells yielding as much as 1,700 gallons per minute are located in San Pasqual Basin.

Ground water movement occurs in a general westerly direction, approximately parallel to the direction of surface flow. Lines of equal elevation and profiles of ground water levels for the spring of 1952 and the fall of 1957 are shown on Plate 7-A.

Since ground water in San Pasqual Basin is unconfined, ground water levels within the basin are responsive to significant changes in the quantity of precipitation on, and runoff passing through, the area overlying the basin. Lines of equal change of elevation of ground water in San Pasqual Basin from the spring of 1952, when the basin was considered essentially full, to the fall of 1957, when ground water levels were the lowest of record, are shown on Plate 8.

Long-term records of depth to ground water are available for several wells in San Pasqual Basin. Fluctuation of water levels in these wells is shown on Plate 9. Records of depths to ground water in the basin indicate that water levels declined consistently during the drought which occurred subsequent to 1943-44. The basin recovered to an essentially full status as a result of the above-normal recharge occurring in 1951-52. During the years following 1951-52, the rate of decline of ground water levels was the greatest of record, dropping as much as nine feet per year in well

No. 12S/1W-36D1, as shown on Plate 9. In the fall of 1957, the estimated average depth to ground water for the entire basin was about 30 feet. The greatest fluctuation of water levels occurs in the eastern portion of San Pasqual Basin, where the greatest recharge occurs and pumping from wells is appreciable in amount. This phenomenon is demonstrated diagrammatically on Plate 7-A where ground water level profiles are illustrated.

San Dieguito Basin. San Dieguito River traverses San Dieguito
Basin and is the main source of recharge to this coastal ground water basin.
Wells used primarily for agricultural purposes, in addition to subsurface outflow to the ocean during periods when ground water levels are above sea level, constitute the principal means of discharge from the ground water body.

Historically, ground water has moved in a general westerly direction toward the ocean. During the recent drought, however, pumping depressions where ground water levels are below sea level have been formed in inland locations and a landward hydraulic gradient has been established, as shown on Plate 7-B.

San Dieguito Basin is a partially confined ground water reservoir

at its westerly end and has a limited recharge area. Consequently, ground water levels within the basin are not as responsive to changes in quantity of precipitation and runoff as are water levels in San Pasqual Basin. Long term records of depth to ground water are not available for San Dieguito Basin. Records of water level fluctuations during the past several years indicate that a marked decline has taken place in water levels. In the central portion of the basin levels have dropped as much as six feet per year. Ground water elevations in the fall of 1957 in San Dieguito Basin are generally believed to be the lowest of record. Water levels in the fall of 1957 were below sea level at a point five miles inland from the coast and were nearly 40 feet below sea level at a point 3.8 miles inland from the coast.

An analysis of records of ground water level fluctuations in the coastal portion of San Dieguito Basin indicates that tidal fluctuations affect water level elevations in wells in this region. Correlation between the regimen of high and low tides and water levels in well No. 145/4W-1Q1, located less than two miles from the coast line, is shown on Plate 9. This relationship indicates either that the water-bearing formation underlying the basin is in hydraulic continuity with the ocean, or that tidal fluctuations are affecting the hydraulic pressure head on the portion of the partially confined aquifer which extends beneath the ocean, or that a combination of both of these phenomena is occurring.

Ramona Basin. Recharge to Ramona Basin in Santa Maria Valley occurs as percolation into the shallow Recent alluvium found along Santa Maria Creek and into the residuum which comprises most of the basin. Discharge from Ramona Basin occurs as pumping from numerous domestic and agricultural wells which, for the most part, yield small quantities of water.

The ground water surface slopes in a westerly direction similar to the slope of the ground surface. Elevation of water levels and direction of ground water movement in Ramona Basin for the fall of 1957 is depicted on Plate 7-C.

Although little Recent alluvium exists in Ramona Basin, ground water levels in most areas of the basin are very responsive to significant changes in magnitude of precipitation and runoff because of the permeable nature of the residuum. Ground water levels approximately one mile northeast of the community of Ramona rose over 20 feet in the spring of 1952 as a result of above-normal precipitation and runoff. Water levels in the basin have declined rapidly during the drought which has occurred since that time, dropping as much as five feet per year in some areas, as shown on Plate 9. Ground water level elevations in the fall of 1957 in Ramona Basin were generally the lowest of record.

Felicita Basin. Felicita Basin, located in the hilly area between Lake Hodges and the boundary of the San Dieguito River watershed south of the City of Escondido, consists of relatively shallow residuum. In addition to percolation of precipitation below the root zone, recharge to Felicita Basin is derived from applied water, most of which is imported into San Dieguito River watershed through facilities of the City of Escondido, Rincon del Diablo Municipal Water District, and Escondido Mutual Water Company. By far the largest proportion of this imported water is Colorado River or San Luis Rey River water, as previously discussed.

Effluent flow occurs from Felicita Basin and is evident in small unnamed intermittent and perennial watercourses which extend in a southerly direction into Lake Hodges Basin. The major source of discharge from the basin is extraction of water from wells. Many of these are uncased installations with horizontal laterals, producing moderate quantities of water for beneficial use.

Ground water moves in a southerly direction toward Lake Hodges.

The direction of movement is indicated on Plate 7-D, showing lines of equal elevation of ground water levels for Felicita Basin for the fall of 1957.

Lake Hodges Basin. Lake Hodges Basin lies south of the City of Escondido and Felicita Basin and lies north and east of Lake Hodges.

Recent alluvium overlies the residuum within Lake Hodges Basin. Recharge to ground water occurs principally from surface and subsurface flow from San Pasqual and Felicita Basins. Lake Hodges Basin is, at times of high reservoir stages, replenished, in part, by percolation of water stored in Lake Hodges; however, subsurface flow from the basin usually moves toward the reservoir.

The principal discharge from Lake Hodges Basin is pumpage through wells of the Green Mutual Water Company of San Diego.County. This company supplies water for irrigation of avocado and citrus groves and for domestic use on the hilly areas bordering Lake Hodges Basin on the west, north, and east.

Long-term records of ground water level fluctuations in Hodges
Basin are not available, but movement of ground water and elevation of ground
water levels within the area for the fall of 1957 are shown on Plate 7-D.

Quality of Water

A study of the mineral quality of waters within the San Dieguito River watershed was undertaken to determine the suitability of these waters for irrigation, domestic, and municipal use and to detect the occurrence of any mineral quality impairment.

The data used in this study included 139 complete and 7 partial analyses of ground water and 32 complete and 8 partial analyses of surface water. These included a large number of samples taken and analyzed by the State Department of Water Resources. The remainder of the analyses used have been obtained from cooperating agencies.

The evaluation of present water quality is based primarily upon 73 complete analyses of ground water, and 7 complete analyses of surface water, from samples collected early in 1957.

Complete mineral analyses include the determination of the concentration of four cations: calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K); five anions: carbonate (CO3), bicarbonate (HCO3), chloride (Cl), sulfate (SO4), and nitrate (NO3); total dissolved solids; boron (B); fluoride (F); and computed values of per cent sodium and total hardness.

In general, for purposes of this investigation, the partial analyses include determinations of chloride and bicarbonate ion concentrations, electrical conductivity, and total hardness.

Specific terms as used in succeeding water quality discussions are listed and defined as follows:

Quality of Water. Those physical and mineral characteristics of water affecting its suitability for beneficial uses.

Degradation. Any impairment of the quality of water due to causes other than disposal of sewage and industrial wastes.

Pollution. Impairment of the quality of water by sewage and industrial waste to a degree which does not create an actual hazard to public health, but which adversely and unreasonably affects such water for beneficial uses.

Contamination. Impairment of the quality of water by sewage or industrial wastes to a degree which creates a hazard to public health through poisoning or spread of disease.

Hardness. A characteristic of water which causes coagulation and increased consumption of soap, deposition of scale on boilers, injurious effects in some industrial processes, and, on occasion, objectionable taste. Hardness is due in large part to the presence of salts of calcium, magnesium, and iron.

Character of Water. The predominant cation and anion identify the character of water. For example, water which is sodium bicarbonate (NaHCO3) in

character contains sodium and bicarbonate ions in excess of 50 per cent of the total cations and anions expressed as equivalents.

Standards of Quality for Water

Investigation of the quality of surface and ground waters of the San Dieguito River watershed, as reported herein, is limited to the consideration of the mineral constituents of the waters, with reference to their suitability for irrigation and domestic use.

The factors which were used as a guide in determining suitability of water for irrigation use comprise the following: (1) chloride concentration; (2) total dissolved solids, as measured by electrical conductance; (3) boron concentration; and (4) per cent sodium.

The significance of these factors is as follows:

- l. The chloride ion is found in varying concentrations in irrigation waters. It is not considered essential to plant growth, and excessive concentrations will inhibit growth.
- 2. The amount of total dissolved solids, as indicated by electrical conductivity (ECxl0⁶ at 25°C), furnishes an approximate indication of the over-all mineral quality of the water. For most natural waters, total dissolved solids in parts per million (ppm) are approximately equal to 0.7 of the electrical conductivity. The presence of excessive amounts of total dissolved solids in irrigation water will reduce crop yields.
- 3. Crops are sensitive to boron concentration, although they generally require a small amount (less than 0.1 ppm) for growth. Most plants will not tolerate more than 0.5 to 2 ppm of this element.
- 4. Per cent sodium reported in the analyses is the ratio of the sodium cation to the sum of all cations and has been obtained by dividing sodium by the sum of calcium, magnesium, potassium, and sodium, all expressed

in equivalents per million (epm), and multiplying by 100. Water containing high per cent sodium has an adverse effect upon the physical structure of the soil by dispersing the soil colloids and making the soil "tight", thus retarding movement of water through the soil, retarding the leaching of salts, and making the soil difficult to work.

This Department uses a classification, based on these four factors, which separates water to be used for irrigation purposes into three general types. This classification is presented in the following paragraphs, taken from "California Agriculture", October, 1950.

"Because of diverse climatological conditions, crops, and soils in California, it has not been possible to establish rigid limits for all conditions involved. Instead, irrigation waters are divided into three broad classes based upon work done at the University of California and at the Rubidoux and Regional Salinity Laboratories of the U. S. Department of Agriculture.

- "Class 1. Excellent to good Regarded as safe and suitable for most plants under any condition of soil or climate.
- "Class 2. Good to injurious Regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.
- "Class 3. Injurious to unsatisfactory Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant."

Tentative standards for irrigation waters have taken into account four factors or constituents, as listed below:

	Class 1 excellent to good	Class 2 good to injurious	Class 3 injurious to unsatisfactory
Conductance (ECxlo ⁶ at 25°C)	Less than 1,000	1,000 - 3,000	More than 3,000
Boron, ppm Per cent sodium Chloride, ppm	Less than 0.5 Less than 60 Less than 175	0.5 - 2.0 60 - 75 175 - 350	More than 2.0 More than 75 More than 350

Probably the most widely used criteria for determining the suitability of water for domestic and municipal use are the "United States Public Health Service Drinking Water Standards, 1946", which have been adopted by the State Department of Public Health. These standards establish mandatory limits for certain constituents and recommended limits for others. The mandatory limits, in ppm, are as follows:

Lead		0.1
Fluoride		1.5
Arsenic		0.05
Selenium		0.05
Hexavalent	chromium	0.05

Nonmandatory but recommended limits, in ppm, are as follows:

Copper	3.0
Iron and manganese together	0.3
Magnesium	125
Zinc	15
Chloride	250
Sulfate	250
Phenolic compounds in	
terms of phenol	0.001
Total dissolved solids,	
desirable	500
Total dissolved solids,	
permitted	1,000

Total hardness is a significant factor in the determination of the suitability of a water for domestic and municipal use. Waters containing 100 ppm or less of hardness (as CaCO₃) are considered as "soft", 101-200 ppm "moderately hard", and those with more than 200 ppm "very hard".

In addition to the above quoted standards, the State Department of Public Health has recommended a tentative limit of 10 ppm nitrate nitrogen as N (44 ppm nitrate as NO3) for domestic waters. Any water containing higher nitrate concentrations may be considered to be of questionable quality for domestic and municipal use.

It should be noted that no bacterial analyses have been made, and discussion of suitability of waters for domestic and municipal purposes

is limited to considerations of mineral quality.

Quality of Surface Water

Surface water analyses are available from 15 sampling points distributed throughout the San Dieguito River watershed. These analyses are contained in Table F-1 of Appendix F. Typical analyses of surface waters are presented in Table 7, and the locations of the sampling points are shown on Plate 4. The stream mile sampling point numbers shown in Table 7 indicate the stream, tributary, and location of the sampling point. The first number denotes the major stream system, and the last number represents the number of miles upstream on an individual tributary. Intermediate numbers are mileages to successive stream confluences. For example, number 96-26.0-2.0 refers to a sampling point on a tributary of San Dieguito River which has its confluence located 26.0 miles upstream from the ocean, i.e., Guejito Creek. The sampling point is 2.0 miles up Guejito Creek from the confluence.

TABLE 7

TYPICAL MINERAL ANALYSES OF SURFACE WATER IN SAN DIEGUITO RIVER WATERSHED[®]

				200		1										1				1
Stream	Plets 4:	Streem		oharge,: ECxlo6	ECx106	· · · · · · · · · · · · · · · · · · ·	Mine	Mineral constituents in	t1 tuent	a th	parts	perts per million equivalents per million	r mill	E I		£ 5	B, : dis-	i. ha.		Per
location :		sampling point	Tingb	: feet :	25°		 ຢ່ ບ	74. 186	Ne.	ж.		HCO ₃	. SQ.		NO ₃		los: md	ng L	00 90	2
Santa Tsabel Greek, State Highway Route No. 79	н	96-49.5	1-27-57 1420	° _N	316	7°#.	1.30	0.50	0.76	0.07	00	1.30	0.083 0.00	0.55	्र ह	900	0 213	•		29
Senta Ysabel Creek, at Sutherland Reservoir	N	96-41.1	10-16-57 ^d	1	1462	8.8	1.20	1.23 1	38 8	0.20	0.20	2038	20 h 0.42 1	1.39	0.01	- 6.0	280		128	£4
Santa Yaabel Creek, near Ramona, U.S.G.S. Gaging Station	at so	%-33.8	3-26-57 1430	•	770	7.7	2.50	2.30	2.87 0	0.06	00	3.30	2.00	81 2.28 T	i i	0.3 0.	0.06		239	×
Santa Yaabel Creek, near San Pasqual, j U.S.G.S.	20	%-29.5	1-10-57	0.1	*	7.3	2.15	3.12	3.83	00.10	00	23.52 3.52 1.18 1.18	1:73	3.89	00.01	•	0.11 600		263	# 2
Guejito Creek, near San Pasqual, U.S.G.S. Gaging Station	8, 8	%-26.0-2,	%-26.0-2.0 1-13-57 1345	90	459 †	7.3	2.00	1.89 2	2.35	0.07	00	3.06	1:11 2	72 2.03	17. 17.	0	0.04 380		₹.	34
San Dieguito River at Lake Hodges outlet	큐	%-12.2	1-29-57 ^d	4.6 1,270	1,270	8.0	25.74	2.96 5	5.39 0	0.18	00	2,62 7	7.49	3.59	0.02	6.9	850		380	F 2

Analyses by State Department of Water Resources unless otherwise indicated. Pagific Standard Time indicated by 24-hour time system.

Estimated. Analyses furnished by City of San Diego, Water Department. Furnished by United States Geological Survey, Surface Water Branch, Los Angeles, California.

An evaluation of these analyses shows the waters of the Inland Hydrologic Unit to be of good mineral quality. The mineral character of these waters is variable, but generally bicarbonate and chloride ions are the dominant anions. No cation appears to be dominant in these waters. The total dissolved solids content is indicated by the analyses to be generally less than 600 ppm and chloride content less than 140 ppm. The sodium percentage is less than 45. These waters are considered to be in Class 1 for irrigation use and are well within the limits for recommended drinking water standards.

The runoff from the Inland Hydrologic Unit is tributary to Sutherland Reservoir in the Inland Unit and Lake Hodges in the Central Hydrologic Unit. The quality of the water in Sutherland Reservoir has reflected the good quality of the supply from the Inland Unit. During periods of above-average runoff, the quality of water in Hodges Reservoir should approach that of the inflow from the Inland Hydrologic Unit. Since November, 1948, Colorado River water has been stored in this reservoir. During drought periods, the reservoir contains a large percentage of this imported water and its quality approaches that of Colorado River water. This water is sodium-calcium sulfate in character. Its electrical conductivity exceeds a value of 1,000 and it is considered to be in Class 2 for irrigation water supplies. This water is usable for domestic use although its sulfate content exceeds recommended non-mandatory drinking water standards.

Throughout the Coastal Hydrologic Unit, surface waters are usually of good quality except in the coastal fringe areas where saline tidal sloughs are found.

Quality of Ground Water

Ground water basins in the eastern portion of the San Dieguito River watershed receive water from direct precipitation and runoff from adjacent highlands. These sources are generally of excellent mineral quality. As the basins are not extensively developed, there is little re-use of water or resultant salt build-up in the ground water and ground water quality is generally good.

All available ground water analyses are included in Table F-2 of Appendix F. From these analyses, a group considered to be typical have been selected and are shown in Table 8. The location of the wells from which representative samples were collected is shown on Plate 4. The ground water quality in each of the hydrologic units of the San Dieguito River watershed is presented hereinafter.

Per Sen Ne		6:1			ř		ਜ਼ ਜ਼		Oi _I			94	*
Tokal hardness as CaCO3s		185			317		218		60 80 80 80 80 80 80 80 80 80 80 80 80 80			\$0t ₁	705
: Total : : diz- : :solved : :solide,:		064			821		864		673			889	2,350
Bs in ppm		0			0,10		0		0.05			0.13	0,35
F, In ppm		η°O			9°0		₽°0		9°5			0°1	ħ°0
No		148			1.3		0.3		0.02			0.11	0.08
: 61		143			3.98		153		3.30			6.40	24.35
parte per million equivalents per million ; HOO; SO _L ; Cl		22 0.46			3.47		0.5%		77.			2.21	1.70
usvalen HCO3	c unit	20,45	IC UNIT	E.	2,82	asin	20.35	asin	415 6.81	IC UNIT	Basin	387 6.35	60%
per coo	HYDROLOGIC Ramona Basin	00	TYDROL OG	Felicita Basin	olo	Lake Hodges Basin	00	San Pasqual Basin	00	YDROLOG	San Dieguito Basin	00	00
entes In	INLAND HYDROLOGIC UNIT	0.08	CENTRAL HYDROLOGIC UNIT	Felic	0,00	Lake F	3.07	San Pe	0.05	COASTAL HYDROLOGIC UNIT	San Di	5.00	25 0.65
constituents in		3.65			5.22		3.17		100			7.09	19.00
Mineral . Mg		3.80			4.03		2,21		3.53			3,70	7.05
		39			2034		2.15		25 A			88 1, 10	141 7.05
I d.		7.5			7.8		7.6		7.5			7.7	2.6
:Temper~: : ature : ECx30 : when : at :sampled: 25°C		795			1,197		820		1,307			1,945	000 مىل
Temperature survent sampled:		20			62		19		69			99	99
Date		3-26-57 ^b			3-56-57		4- 5-57b		3-26-57			3-27-57	3-26-57
State well : mumber		13S/1E-15E2			12S/2W-2UR3		135/2W- 2L1		135/14- 3E1			38/34-3316	145/34- 5K2
								1	2				

a. Analyses by State Department of Water Resources unless otherwise indicated. b. Analyses by Terminal Testing Laboratories, Inc., Los Angeles, California.

Inland Hydrologic Unit. Ballena, Lower Hatfield, Upper Hatfield,
Pamo, East Santa Teresa, West Santa Teresa, and Santa Ysabel Basins are
smaller basins located within the Inland Hydrologic Unit and appear to
contain ground waters of similar character and quality. Analyses of quality
are available from nine wells distributed throughout these basins. The cations
in these waters appear to be balanced, with no single cation predominating.
Bicarbonate is the predominant anion. The total dissolved solids content of
these waters ranges from about 170 to 420 ppm, while the chloride content
ranges from about 15 to 70 ppm. The sodium percentage ranges from 28 to
45. The boron content of these waters is very low, being less than 0.1 ppm.
These are Class 1 irrigation waters and meet the recommended drinking water
standards, although generally they are moderately hard.

Only one analysis of ground water quality from the small basin of Wash Hollow is available. This analysis indicates a total dissolved solids content of 700 ppm and chloride content of 133 ppm. The sodium percentage is 40 and no boron was detected. This is a Class 2 irrigation water which meets the recommended drinking water standards.

Ramona Basin is the largest ground water basin in the Inland Hydrologic Unit. Thirty-two analyses of ground water quality are available from thirteen wells located within this basin. These waters generally vary in character from sodium bicarbonate to sodium chloride. They are quite variable in quality. Their total dissolved solids content varies from about 250 to 1,050 ppm, while chloride content ranges from approximately 70 to 310 ppm. The sodium percentage does not exceed 63 and boron does not exceed 0.2 ppm. These waters, dependent on the source within the basin, are in Class 1 or Class 2 for irrigation use and are suitable for domestic use. Water from two wells was found to contain nitrates in excess of the recommended

drinking water standards, while two others contained chlorides in excess of 250 ppm.

Central Hydrologic Unit. San Pasqual, Lake Hodges, and Felicita
Basins are located within the Central Hydrologic Unit. The water quality in
these basins is generally poorer than that found in the basins of the Inland
Hydrologic Unit.

Thirty-six analyses of ground water quality are available from twenty wells in San Pasqual Basin. These analyses show waters which range in character from calcium-sodium bicarbonate to sodium chloride. The total dissolved solids content of these waters ranges from about 300 to 1,600 ppm, while the chloride ion content ranges from approximately 45 to 450 ppm. The sodium percentage varies from 33 to 58 and the boron content does not exceed 0.3 ppm. These waters are generally considered to be in Class 1 or Class 2 for irrigation use, although analyses of two well waters showed chloride concentrations exceeding 390 ppm, placing those waters in Class 3.

Although excessive chlorides and total dissolved solids were found in three well waters in San Pasqual Basin, ground waters in the basin are generally suitable for domestic use. Ground water in this basin varies between moderately hard and very hard. The better quality ground waters are located in the northerly and easterly portions of the basin.

Six ground water analyses are available from three wells located in Lake Hodges Basin. The predominant cations as indicated by these analyses are bicarbonate and chloride. The anions appear to be approximately balanced. The total dissolved solids range from 498 to 790 ppm, while the chloride content ranges from 124 to 176 ppm. These waters are generally in Class 2 for irrigation use, and meet the recommended standards for drinking water. However, they are generally very hard.

eight wells. These analyses show that the ground water is similar in character to the ground water found in Lake Hodges Basin. The total dissolved solids content of these waters ranges from 480 to 1,000 ppm, while the chlorides range from 105 to 260 ppm. Sodium percentage ranges from 31 to 48 and boron does not exceed 0.1 ppm. These ground waters are usually considered to be Class 2 irrigation waters. The nitrate content of these waters ranges from 46 to 130 ppm and exceeds the recommended limit for drinking waters.

Coastal Hydrologic Unit. The largest ground water basin in the Coastal Hydrologic Unit is San Dieguito Basin. Forty-three analyses of ground water quality from 25 wells were used in the study of water quality in this basin. These analyses show that the waters are generally poor in quality. The better quality waters are found in the northeastern portion of the basin, near Rancho Santa Fe. In this area, four of seven wells produce Class 2 irrigation waters and are also suitable for domestic use. The remaining wells in this area are considered to be in Class 3 for irrigation use. These waters contain concentrations of chlorides and total dissolved solids which exceed the recommended drinking water standards and are classed as very hard for domestic use.

Well No. 145/3W-8M1, in Gonzales Canyon, contains water of good quality. The water contains total dissolved solids of about 500 ppm and chlorides of 140 ppm. It is considered to be in Class 1 for irrigation use and meets the recommended drinking water requirements.

Analysis of samples of the remaining ground waters in San Dieguito Basin indicates that they are Class 3 irrigation waters containing excessive total dissolved solids and chlorides. They are very hard and are not recommended for domestic use.

Nine analyses of ground water from wells located throughout the remainder of the Coastal Hydrologic Unit are available. These analyses indicate that the water is generally of poor quality. Seven wells contain Class 3 irrigation waters, while only two contain waters of Class 2. These waters generally have high total dissolved solids and chloride content and usually are not suitable for domestic use.

Water Quality Problems

The most significant water quality problems within the San
Dieguito River watershed are found in the San Dieguito Basin. Here, high concentrations of dissolved minerals result in water of poor quality throughout most of the basin. Water found nearest the coast has characteristics similar to sea water and is unusable for domestic, municipal, and irrigation purposes. As there is limited industrial development within this watershed and no major problems of sewage disposal, there are no known instances of ground water pollution.

The only major sewage discharge within the inland portion of the San Dieguito River watershed is at Ramona, where a discharge of approximately 20,000 gallons per day evaporates or percolates into the granitic residuum adjacent to Santa Maria Creek. There is no indication that this operation poses an immediate water quality problem, although a problem may arise if the quantity of discharge is increased or if the surrounding area becomes urbanized.

Waters in the Felicita Basin contain high nitrate concentrations.

These concentrations may tend to inhibit extensive use of these waters for municipal or domestic purposes.

Total dissolved solids in high concentrations are found in many

individual wells throughout the watershed. However, this is not considered a general problem in any ground water basin except San Dieguito Basin.

Sea-Water Intrusion. Analyses indicate that water with characteristics similar to sea water is present in the coastal portion of San Dieguito Basin. This brine underlies an area extending approximately one and one-fourth miles inland from the Pacific Ocean. Within this zone, the waters are highly saline and unsuitable for most domestic, municipal, and irrigation uses.

As previously discussed, a partially confined ground water body lies adjacent to the coast. The extent, thickness, and uniformity of the formations creating this pressure zone have not been completely determined. Under natural conditions, the piezometric head of ground water in the fresh water aquifers was sufficient to prevent vertical percolation of sea water from salt marshes adjacent to the coast and lateral intrusion through outcrops occurring seaward of the shore line.

The drilling of wells through the confining formation and the lowering of pressure levels through ground water development has created conditions permitting intrusion of salt water. Salt water may be entering the basin by one or more means, such as vertical percolation through discontinuities in the confining layer, interconnection of fresh water aquifers and salt marshes by wells near the coast, and lateral seepage from the ocean. It may be anticipated that the quality of water in the coastal area will continue to deteriorate as the landward gradient increases during periods of heavy extractions or drought.

Available records indicate that the landward movement of sea water is progressing slowly. This slow advance may be due to "tight" alluvial deposits in the valley fill. These deposits of low permeability appear to

form a partial barrier to landward movement. However, analyses of water from well No. 145/4W=1211 show a definite change in both character and quality of the water between 1955 and 1957, and the sea-water characteristics of this ground water have become more pronounced. Sea-water intrusion is a definite threat in this coastal area and probably will continue until there is a reversal of the existing landward hydraulic gradient in the area.

Other Water Quality Problems in San Dieguito Basin. Poor quality ground water containing excessive concentrations of dissolved solids and chlorides are found throughout San Dieguito Basin. The character and quality of this water indicates that connate waters may be migrating into this valley from adjacent hills, composed chiefly of Eocene deposits. The distribution of poor quality waters within this basin is shown on Plate 7-B.

The mineral quality of ground waters from the Eocene deposits is exceptionally poor as shown by analyses of waters from wells Nos. 13S/3W-3LK1, 1LS/3W-2Q2, and 1LS/3W-3D1. These analyses are presented in Table F-2 of Appendix F and show chloride contents which exceed 2,000 ppm and total dissolved solids exceeding 6.2400 ppm.

Re-use of water within this basin may also be an important contributing factor in the accumulation of salts in the ground water.

Nitrates in Felicita Basin. Waters from eight wells sampled and analyzed in Felicita Basin during the spring of 1957 were found to contain nitrate concentrations exceeding the tentative limits recommended by the State Department of Public Health. This anion appears in concentrations ranging between 46 and 130 ppm, whereas the recommended limit is set at 44 ppm.

Data are insufficient to isolate the cause of the high nitrate content in the water. However, cesspool and septic tank sewage disposal is prevalent in portions of this basin. This could be the major contributing source, as sewage effluent can add significant quantities of nitrate to the ground waters. According to data presented in Publication No. 9, State Water Pollution Control Board, "Studies of Waste Water Reclamation", 1954, the average increments in mineral constituents attributable to domestic use of water included 20 to 40 ppm total nitrogen (equivalent to 88 to 176 ppm as nitrate). It is, therefore, apparent that the disposal of domestic sewage through septic tanks and cesspools can provide a continual increment of nitrates to ground water.

Agricultural fertilizers, used in the growing of avocados and citrus, are a second possible source of nitrates. Some nitrates contained in the fertilizers are dissolved and leached by irrigation waters and transported to the ground water. "Nitrogen Fixation" in the soil by bacterial action is a third source which could contribute to the increase in nitrate concentration. Caution should be exercised when using waters with a high concentration of nitrates as a domestic supply.

Yields of Presently Developed Water Supply

Water supply development in San Dieguito River watershed has occurred through construction and operation of hundreds of water wells, a few minor surface diversions, numerous small farm ponds, and Hodges and Sutherland Reservoirs. The major source of water supply for use within the watershed has been the yield from ground water basins, both in the valleys and hilly areas. Imported Colorado River water is also an important source of supply. Yields from Hodges and Sutherland Reservoirs are, for the most part, diverted to points of use outside the watershed.

Ground Water Developments

Ground water levels within San Dieguito River watershed have declined to historic low elevations in recent years. However, except in San Dieguito Basin where an overdraft condition appears to exist, the drop in levels can be primarily attributed to the current drought rather than to overdrafts on available supplies. Little additional development of the ground water resources within the watershed can be achieved, except in San Pasqual and Main Lake Hodges Basins, where additional well drilling and construction of pipe line distribution systems would be required for further development of any significant magnitude. Development and operation of San Pasqual and Lake Hodges Basins are discussed hereinafter in Chapter IV under "Plans for Water Development". The relationship between ground water storage depletion and average elevation of the ground water level in San Pasqual and San Dieguito Basins is also discussed and is illustrated on Plate 10.

Present net draft on each of the ground water basins in San Dieguito River watershed is presented in Table 9.

ESTIMATED SEASONAL YIELD OF LOCAL AND IMPORTED WATER SUPPLIES IN SAN DIEGUITO RIVER WATERSHED

In Acre-Feet

	••	Present	ly develop	Presently developed safe yield from existing facilities	ld from ex	isting faci	lities	
	Ground	water	S	Surface water		Net import	port:	
	•	Transfer		Transfer:	••	••		
		from San	: Suther-	: from :	00	From :	••	Total
Hydrologic Unit	: Net :	Pasqual	: land	: Hodges :	:Available:First and	First and :	From	yield
and Subunit	: draft	Basin to	: and	:Reservoir: for use :	for use:	Second	:San Luis :	:available
	:(1956-57):	Lake	: Hodges	to :	outside :	<pre>. outside :San Diego :Rey River: for use .watershed.Amseducts^D (1056-57). within</pre>	Rey River: (1056=57)	for use
		Basin	volrsa	- }			:	watershed
Inland lintt								
Sutherland Subunit	30		1,100		-1,100			30
Pamo Subunit	250		0		0			. 250
Ramona Subunit	1,840		0 (0 0			1,840
Guejico Subunit Rođen Subunit	1 1 1		> C		o c			i ru
Subtotals	2,170		1,100		-1,100			2,170
+ % 11 12								
San Pasqual Subunit	4,240	~500	0	0	0	370	380	064,4
Hodges Subunit	1,230	+500	7,100	-2,220 ^d	4, 880 4, 14, 14, 14, 14, 14, 14, 14, 14, 14, 1	3,070	2,370	7,170
) t)	200	91161	33364	2	2	2006
Coastal Unit	2,020°		0	+2,220 ^d	0	1,430	0	5,670
TOTALS	099 66		8,200	0	-5,980	018,4	2,750	19,500

Minus sign indicates items tending to decrease net supply available for use within subunit and plus sign indicates items tending to increase net supply available for use within subunit. NOTE:

Average seasonal draft from Sutherland and Hodges Reservoirs operated coordinately for the period 1914-15 through 1956-57 to provide a combined safe seasonal yield of 8,200 acre-feet. ಹ

San Diego County Water Authority, further proportioned by present use inside and outside watershed. Assumes both aqueducts flowing full and 1956-57 proportional share of each member agency of the Excludes an estimated 800 acre-feet per season overdraft in San Dieguito Basin.

Estimated portion of commitments of City of San Diego to Santa Fe Irrigation District and Del Mar Utilities available for use in San Dieguito River watershed.

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Surface Water Developments

Construction of the concrete multiple-arch Hodges Dam, located on the San Dieguito River about 12 miles upstream from the ocean, was completed in 1919. Extensive reconstruction was undertaken by the City of San Diego in 1936 to strengthen the structure. The storage capacity of Hodges Reservoir, originally 37,700-acre-feet, has been reduced to approximately 33,500 acre-feet as a result of sedimentation. Releases from Hodges Reservoir are conveyed approximately five miles westerly to San Dieguito Reservoir, located on a minor tributary of Escondido Creek. From this City of San Diego reservoir, having a capacity of 1,100 acre-feet, water is delivered to the City of San Diego, San Dieguito and Santa Fe Irrigation Districts, and Del Mar Utilities.

Construction of Sutherland Dam on Santa Ysabel Creek, about six miles northeast of Ramona, was started by the City of San Diego in 1927, but was not completed until 1954. Sutherland Dam, a concrete multiple-arch structure, provides a reservoir with a gross storage capacity of approximately 29,700 acre-feet. Water diverted from Sutherland Reservoir is transported to the 90,200 acre-foot capacity San Vicente Reservoir on San Vicente Creek, tributary to the San Diego River. San Vicente Reservoir is owned by the City of San Diego and is the terminus of the existing San Diego Aqueduct. From San Vicente Reservoir, water may be conveyed to the City-owned El Capitan Reservoir on the San Diego River, when there is a sufficient differential in reservoir levels, or discharged directly into the City's distribution system.

Yields from Hodges and Sutherland Reservoirs for the period 1914-15 through 1956-57 under coordinate reservoir operation, assuming present conditions of land and water use in San Pasqual-Main Lake Hodges Basin, are presented in Table 9. Location of these reservoirs is shown on Plate 1.

Intermittent diversions from Santa Ysabel Creek in the eastern and western portions of San Pasqual Valley by individuals and private water companies have occurred for many years. The only records available of these diversions, which are generally small in magnitude, are measurements of flow in East and West San Pasqual Ditches before 1916.

Import

For the purpose of estimating the yield from the presently developed water supply within San Dieguito River watershed, the imported supply available from the San Diego County Water Authority is assumed to be equal to the 1956-57 proportional rights of the member agencies of the Authority within the watershed to waters of the existing San Diego Aqueduct and the first barrel of the Second San Diego Aqueduct, now under construction, further proportioned by the present water use inside and outside the watershed. The presently developed imported supply from San Luis Rey River is assumed to be equal to the 1956-57 import from this source.

Estimated values of present yields from ground water supplies, safe yields from Hodges and Sutherland Reservoirs, and yield from the presently developed imported supplies are presented in Table 9.

CHAPTER III. WATER UTILIZATION AND REQUIREMENTS

The historical use of water in San Dieguito River watershed has been discussed in Bulletin No. 55. The present use of water in the watershed is chiefly for agricultural purposes. This demand is satisfied principally from imports and withdrawals from ground water storage and, to a lesser extent, by diversion from surface streams.

On the whole, acreage devoted to irrigated agriculture in the watershed has increased during the last several decades. A decrease has occurred in Santa Maria Valley during recent years as a result of the severe drought and the absence of imported supplies. Decreases have also occurred within Santa Fe Irrigation District as a result of an increase in urban and suburban use. An increase in the latter type of use has occurred in San Dieguito River watershed in recent years, reflecting the general increase in population and the consequent urban and suburban development that has occurred at a remarkable rate in San Diego County since about 1940.

As local water resources are developed and additional imported supplies are made available in the future, it is estimated that both irrigated acreage and areas devoted to urban and suburban use will increase in the watershed.

Water utilization and requirements are discussed in this chapter under the general headings: "Ground Water Extractions", "Appropriation of Water", "Land Use", "Unit Use of Water", "Factors of Water Demand", "Water Requirements Within San Dieguito River Watershed", "Supplemental Water Requirements Within San Dieguito River Watershed", "Water Requirements of the City of San Diego", and "Supplemental Water Requirements of the City of San Diego".

Ground Water Extractions

It is estimated that there are about 1,000 wells in San Dieguito River watershed, of which 750 were examined in the field. Of the active wells in the watershed, it is estimated that approximately 285 wells supply water to meet irrigation requirements, 285 wells are used for domestic purposes, and approximately 30 wells supply water for stock.

Estimated number of active wells, their use, and magnitude of ground water withdrawals, based on consumptive use and an assumed irrigation efficiency of 70 per cent, for each of the ground water basins in the watershed, are presented in Table 10.

TABLE 10

NUMBER OF ACTIVE WELLS AND GROUND WATER EXTRACTIONS
FROM BASINS IN SAN DIEGULTO RIVER WATERSHED

0 0 0 0	Numb	er of acti	ve wells lo	ocated	: Estimated : ground water
Ground water : basin :	Irriga- tion	: :Domestic :	: Stock	: Total	:extractions in : 1956-57, in : acre-feet
Inland Unit					
Ballena East Guejito West Guejito Upper Hatfield Lower Hatfield Pamo Ramona East Santa Teresa West Santa Teresa Santa Ysabel Wash Hollow	1 5 47 2 1	8 1 1 141 3 6 2	2 3 3	11 1 10 199 7 1	50 10 b 290 130 2,510 50 10
Subtotals	58	166	19	243	3,080
Central Unit					
Felicita Green Hidden Highland Lake Hodges Reed San Pasqual	100 3 4 1 20 1	50 2 12	2	150 4 4 3 34 1 102	2,380 580 40 110 360 20 4,640
Subtotals	196	95	7	298	8,130
Coastal Unit					,
La Jolla San Dieguito	28	5 19	1	6 48	2,510
Subtotals	29	24	ı	54	2,510
TOTALS	283	285	27	595	13,720

a. Approximately 0.7 per cent of basin lies within Central Unit. There is no known use of ground water in this portion of the basin.

b. Pumpage estimated to be less than 10 acre-feet.

Appropriation of Water

Since the effective date of the Water Commission Act of December 19, 1914, 38 applications to appropriate water from streams in the San Dieguito River watershed have been filed with the State Water Rights Board or its predecessors. Applications filed through January 1, 1958, are listed in Appendix G, together with pertinent data on the status of the applications, and location and amount of the diversions. The applications, permits, and licenses listed in Appendix G for the appropriation of water do not include appropriative rights initiated prior to the Water Commission Act, riparian rights, correlative rights of overlying owners in ground water basins, nor prescriptive rights which may have been established on either surface streams or underground basins. In general, a comprehensive definition of all rights to a particular water source may only be established by court decree.

Significant to the further development of the water supply within San Dieguito River watershed are the following applications by the City of San Diego to appropriate water:

			APPROXIMATE LOCATION OF	AMOUNT		
	D		-	OF		
APPLICATION			POINT OF			0
NUMBER	FILED	Source	DIVERSION	PERMIT	PURPOSE	STATUS
2315	4-20-21	SAN DIEGUITO RIVER	HODGES DAM	37,700 AF	MUNICIPAL	CERTIFICATE
11658	12-12-46	SANTA YSABEL CREEK	SUTHERLAND DAM	50 CFS	MUNICIPAL	PERMIT
				AND 50,000 AF		
11658	12-12-46	SANTA YSABEL CREEK	PAMO DAM SITE	130,000 AF	MUNICIPAL	PERMIT
11 658	12-12-46	SAN DIEGUITO RIVER	HODGES DAM	230,000 AF	MUNICIPAL	PERMIT

Water Rights Litigation

In May, 1956, certain landowners in San Pasqual Valley brought suit against the City of San Diego, in the Superior Court of the State of California in and for the County of San Diego, over operation of the City's Sutherland

Reservoir located upstream from San Pasqual Valley on Santa Ysabel Creek. The action, entitled Stanley Trussell, et al., plaintiffs, vs. The City of San Diego, a Municipal Corporation, defendant, went to trial in October, 1957, and judgment was entered December 17, 1957, in favor of the plaintiffs. The City of San Diego filed an appeal in March, 1958, before the Fourth District Court of Appeals, and hearings are tentatively scheduled to be held in 1959.

The trial court declared in its judgment that the plaintiffs are owners of rights in and to the waters of Santa Ysabel Creek which are prior and paramount to the appropriative rights of the defendant, the City of San Diego, and are entitled to have sufficient amounts of both surface and subsurface flow of Santa Ysabel Creek available to meet their reasonable requirements for beneficial use on their lands within the watershed without interference or interruption by the defendant. The Court further ruled that the plaintiffs are not obliged to change their long-established methods of diversion and use of waters of Santa Ysabel Creek and are entitled to have the normal static ground water level underlying their lands remain as it would have been if Sutherland Dam had not been built. The Court enjoined the City of San Diego from storing or withholding any of the natural flow of Santa Ysabel Creek upstream from the plaintiff's lands whenever the static water level underlying said lands is 20 feet or more below the surrounding ground surface.

The City of San Diego has reported that the judgment of the trial court seriously restricts their use of Sutherland Reservoir and that the City plans to acquire the remaining privately-owned land in San Pasqual Valley through negotiation or condemnation proceedings if the decision of the trial court is not reversed upon appeal. Therefore, it was assumed in the operation studies and cost analyses described herein that the City of San Diego would have the right to unrestricted use of Sutherland Reservoir.

The Findings of Fact, Conclusions of Law, and the Judgment of the Court appear in Appendix G to this report.

Land Use

For the purpose of estimating water requirements of San Dieguito River watershed, present land use within the watershed was determined in December, 1956, and January, 1957. Lands devoted to truck crops were surveyed quarterly in 1957 in order to determine average areas devoted to such use. The findings of these surveys is assumed to represent actual land use as of the 1956-57 season. In addition to the determination of present utilization, lands within the watershed were classified in the field as to their suitability for irrigated agriculture and for potential urban and suburban use in order to estimate probable ultimate water requirements.

Past and Present Land Use

In 1888, of the total 220,760 acres within the watershed, there were, reportedly, 175 acres of irrigated agriculture in San Pasqual Valley, 100 acres irrigated in San Dieguito Valley, an additional 100 acres under irrigation in Santa Ysabel Valley, and 25 acres irrigated along Guejito Creek, for a total of about 400 acres under irrigation in the watershed. The total area irrigated in 1934 was approximately 4,500 acres, increasing to 7,300 acres in 1948 and 9,600 acres under present conditions. Approximately 70,000 acres within the watershed are now devoted to nonirrigated agricultural enterprises.

A marked increase in urban development, coupled with an increase in population, has occurred in recent years near Del Mar in the vicinity of U. S. Highway No. 101 and the San Diego County Fair Grounds. The City of Escondido and the community of Ramona have also experienced urban and suburban expansion. About 2,600 acres, or 1.2 per cent of the watershed area, are presently classed as urban and suburban lands.

The population of San Diego County, City of San Diego, and City of Escondido for census years and the year 1957, commencing in 1900, is as follows:

		Population	
	San Diego	City of	City of
Year	County	San Diego	Escondido
3,000	2ť 000	77 700	ort.
1900	35,090	17,700	755
1910	61,665	39,578	1,334
1920	112,248	74,361	1,789
1930	209,659	147,995	3,421
1940	289,348	203,341	4,560
1950	556,808	334,387	6,544
1957	900,400 ^a	494,200 ^a	10,050b

a. Estimate.

The land use survey of the watershed in 1956 and 1957 by the State Department of Water Resources was undertaken as part of the continuing basic data collection program of this Department. A summary of the results of these surveys is given in Table 11 for San Pasqual and San Dieguito Basins and for the entire watershed, and are assumed to represent present conditions. Use of lands within hydrologic units and subunits for 1956-57 is presented in Table H-1 of Appendix H to this report.

b. Special census.

TABLE 11

LAND USE IN SAN PASQUAL AND SAN DIEGUITO BASINS
AND SAN DIEGUITO RIVER WATERSHED FOR 1956-57

In Acres

Class and type of land use	San Pasqual Basin	San Dieguito Basin	:San Dieguito : River : watershed
URBAN AND SUBÚRBAN LANDS			
Residential Commercial Industrial Parks and cemeteries Miscellaneous urban and suburban Vacant Net urban and suburban area	0 0 0 0 74 0	7 148 70 0 32 18	486 296 154 26 924 163
Streets and roads	8	112	503
Gross urban and suburban area	82	387	2,552
IRRIGATED LANDS			
Alfalfa and pasture Avocados Beans Citrus Deciduous and vineyard Hay and grain	828 0 0 38 3	362 1 612 1 6 218	2,363 2,318 612 2,859 108 582
Truck crops	49	80	301
Net irrigated area	1,101	1,280	9,143
Streets and roads	58	<u>67</u>	478
Gross irrigated area	1,159	1,347	9,621
GROSS WATER SERVICE AREAS	1,241	1,734	12,173

LAND USE IN SAN PASQUAL AND SAN DIEGUITO BASINS AND SAN DIEGUITO RIVER WATERSHED FOR 1956-57 (continued)

In Acres

Class and type of land use	San Pasqual Basin	San Dieguito Basin	San Dieguito River watershed
NONIRRIGATED AGRICULTURAL LANDS			
Field crops Pasture and grain Orchard and vineyard Idle and fallow Miscellaneous	0 1,001 0 522 0	255 361 0 825 26	255 51,153 1,314 13,234 613
Net nonirrigated agricultural area	1,523	1,467	66,569
Streets and roads	81	<u>76</u>	3,496
Gross nonirrigated agricul- tural area	1,604	1,543	70,065
NATIVE VEGETATION			
Light brush and grass lands Medium brush Heavy brush and trees Phreatophytes Water surfaces Barren and waste	138 0 47 296 0 96	419 12 10 113 51 	66,948 29,300 34,302 1,832 1,015 2,383
Net native vegetation	577	626	135,780
Streets and roads	11_	11_	2,739
Gross native vegetation	588	637	138,519
GROSS NONWATER SERVICE AREAS	2,192	2,180	208,584
GRAND TOTALS	3,433	3,914	220,757

Probable Ultimate Pattern of Land Use

Land Classification. A reconnaissance land classification survey was undertaken in 1956 as part of the investigation of alternative aqueduct routes to San Diego County. Data from this survey were utilized in this investigation to determine the amount and location of irrigable lands and to estimate the probable ultimate water requirements.

Topography, soil depth, soil texture, salinity and alkalinity of the soil, high ground water level conditions, and presence of rock were physical characteristics considered in classifying the lands. Present agricultural practices, climatic conditions, and ease of irrigation were also considered; however, no consideration was given to those economic factors relating to production and marketing, nor was the availability of a water supply considered. A description of each crop adaptability class and the standards utilized in the survey are contained in Table H-2 of Appendix H.

As a result of the land classification survey, it was found that of the total 220,760 acres within the watershed, approximately 91,600 acres are susceptible of intensive agricultural development, by irrigation, for climatically adapted crops. This irrigable area is comprised of 10,700 acres of valley floor lands and 80,900 acres of hill lands. The hill lands included are those which meet the requirements of irrigable valley lands in all respects except for topography, limiting their suitability to certain crops.

Irrigable valley lands are scattered throughout the watershed, with the major portion of such lands found in San Pasqual, San Dieguito, and Santa Maria Valleys. The principal irrigable hill lands are found near Ramona, Santa Ysabel, in the region drained by Guejito Creek, and the areas

located north and south of Lake Hodges and San Dieguito Valley. Table
H-3 of Appendix H presents a classification of lands in San Dieguito River
watershed by hydrologic units and subunits.

Land Use. Utilizing results of the land classification survey and considering present and probable future trends of development, a pattern of probable ultimate land use was forecast for San Dieguito River watershed for the purpose of estimating probable ultimate water requirements. The pattern of present land use, supplemented by data presented in State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California", 1955, and information on future water requirements in San Diego County presented in Bulletin No. 61, "Feather River Project-Investigation of Alternative Aqueduct Routes to San Diego County", 1957, were analyzed in predicting probable future development.

It was assumed that future extensive urban development in San Diego County would be confined to a narrow coastal strip a few miles in width, including the area at the mouth of the San Dieguito River near Del Mar. The area in the watershed devoted to urban and suburban use is expected to increase to approximately 12,000 acres under ultimate conditions. Approximately one—half of San Dieguito Valley would be devoted to urban and suburban development under ultimate conditions of land use. The suburban area within the watershed south of the City of Escondido is expected to expand and additional urban and suburban development is also anticipated in the vicinity of Ramona and north of Poway.

It is forecast that the ultimate irrigated area within the watershed will be approximately 91,600 acres, comprising principally avocados, alfalfa, and pasture crops. Location and extent of urban and suburban and irrigated lands in San Dieguito River watershed and within the City of San Diego under conditions of present and probable ultimate land use are shown on Plate 11 and Plate 12, respectively. The probable ultimate pattern of land use in hydrologic units and subunits in San Dieguito River watershed is contained in Table H-4 of Appendix H.

Unit Values of Water Use

Estimation of the present and probable ultimate water requirements of the San Dieguito River watershed involved determination of unit values of consumptive use of water for each type of land use and, in the case of irrigated land, for each crop. In view of the availability of consumptive use data developed during prior investigations by the State Department of Water Resources, no field determinations of soil moisture depletion and values of consumptive use of water were undertaken. Among these investigations were the state-wide studies reported in State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California", 1955, and detailed studies in Ventura County and in the Santa Margarita River watershed in San Diego County.

The consumptive use of water data developed for other areas, particularly values applicable to the Santa Margarita River watershed, were reviewed and used where appropriate after proper adjustment for differences in mean monthly temperatures of the areas considered. Unit values of consumptive use of water for various crops in the Inland, Central, and Coastal Units of the watershed are presented in Table H-5 of Appendix H.

That portion of the total seasonal consumptive use satisfied by precipitation was determined from data previously developed for

the Santa Margarita River watershed. Unit values of consumptive use of applied water, defined as total mean seasonal consumptive use minus that portion of the consumptive use satisfied by precipitation, were then computed for various types of land use in the three hydrologic units.

Factors of Water Demand

Anticipated rates, times, and places of delivery of water are factors which must be considered in the planning of water conservation projects and accompanying distribution systems. An evaluation of such factors requires a determination of irrigation efficiencies, irrecoverable water losses, and permissible deficiencies in water application.

Irrigation Efficiency

Even under the most favorable conditions, it is necessary to apply water in excess of that consumptively used by the plants. The ratio of consumptive use of applied water to the total amount of applied water, expressed as a percentage, is termed "irrigation efficiency". This ratio is useful as an indicator of the prevailing irrigation practices. It may also be applied to determinations of the consumptive use of applied water in order to estimate total water requirements when conditions are such that the portion of the applied water which exceeds the consumptive use requirement cannot be recovered and re-used.

Irrigation efficiency varies widely between crops and among plots devoted to the same crop. The variations may be attributed to differences in depth of root zone, soil type, topography, method of irrigation, drainage characteristics, and the practices of the individual irrigators. Based on experience gained in the investigation of water requirements of the Santa

Margarita River watershed, and from observations within the San Dieguito River watershed, 70 per cent was assumed to be the irrigation efficiency for both present and ultimate conditions. For urban and suburban lands, a service area efficiency of water use was assumed to be 50 per cent for both present and ultimate conditions.

Irrecoverable Losses

The term "irrecoverable losses" of water refers to that portion of the transmission and delivery losses and the return flow from irrigated lands which cannot be recovered and re-used within the area under consideration, and to sewage effluent which is discharged to the ocean or otherwise lost for re-use. These losses comprise an additional demand on the water supplies of the watershed or on imported water supplies, over and above consumptive use requirements. It is pointed out that an irrecoverable loss to an upstream unit may constitute an accretion to available water supplies in a lower unit. Irrecoverable losses in specific areas within the watershed are discussed in ensuing portions of this chapter.

Permissible Deficiencies in Application of Water

Temporary seasonal deficiencies in the supply of irrigation water that might be endured without permanent injury to perennial crops were not determined as part of this investigation. Prior studies by the State Department of Water Resources and other agencies indicate that a maximum deficiency of 35 per cent of the full seasonal requirement can be endured if the deficiency occurs only at relatively long intervals of time. It has also been determined that small deficiencies occurring at relatively frequent

intervals can be endured. Studies of the water requirements of the San Dieguito River watershed assume that adequate water supplies will be provided to produce optimum crop yields.

Monthly Distribution of Demand for Water

The City of San Diego furnished data on the monthly distribution of demand for water in their municipal service area for use in the design of conveyance facilities from proposed reservoirs in the San Dieguito River watershed to a connection with the City's distribution facilities. Monthly distribution of demand for water by urban areas within the watershed is based principally on information secured from the City of Escondido. Monthly distribution of demand for agricultural water was developed primarily from data secured from San Dieguito and Santa Fe Irrigation Districts.

Estimated average monthly distribution of seasonal urban and agricultural water demand within the watershed and by the City of San Diego are presented in Table 12.

TABLE 12

ESTIMATED AVERAGE MONTHLY DISTRIBUTION OF SEASONAL URBAN AND AGRICULTURAL DEMAND FOR WATER WITHIN SAN DIEGUITO RIVER WATERSHED AND DEMAND FOR WATER BY THE CITY OF SAN DIEGO

In Per Cent

Month	: San Dieguito R : : Agricultural	iver watershed: Urban and: suburban	City of San Diego
October	12.6	8.2	9.0
November	6.4	6.5	7.8
December	4.2	5.8	7-5
January	1.3	5.8	6.5
February	1.0	5•5	5•9
March	1.5	5.8	6.8
April	3.4	7.4	7.4
May	8.0	9.1	9•3
June	14.3	10.7	9.4
July	15.4	11.6	10.5
August	16.8	12.4	10.4
September	15.1	11.2	9.5
TOTALS	100.0	100.0	100.0

Water Requirements Within San Dieguito River Watershed

Water requirements, as used in this report, refers to the quantity of water necessary to satisfy the estimated consumptive use of applied water and attendant irrecoverable losses. Consumptive use of applied water was estimated by multiplying the acreage of each category of land use, under present and probable ultimate conditions of development, by appropriate unit values of consumptive use of applied water, determined after due consideration of climatological conditions. In areas of the watershed where water applied to lands in excess of consumptive use will return to ground water storage and be available for re-use, water requirements were assumed to be equal to the total consumptive use of applied water.

For lands overlying confined ground water bodies, where it was assumed that water applied in excess of consumptive use is prevented from returning to ground water storage for subsequent re-use, or where sewage is discharged directly to the ocean, water requirements are assumed to approximate the total amount of applied water. The water requirement is then computed by applying the value determined for irrigation efficiency, in the case of irrigated lands, and the assumed service area efficiency of 50 per cent, in the case of urbanized areas, to the quantity of water necessary to meet the estimated consumptive use.

Present Water Requirement

The State Department of Water Resources surveys of 1956 and 1957 are considered to be representative of present (1956-57) land use in the San Dieguito River watershed. Under present conditions of land use, it was

assumed that water requirements were equal to the consumptive use of applied water since in most areas within the watershed the irrecoverable losses were assumed negligible, except in the coastal portion of San Dieguito Basin. In this basin, irrecoverable losses occur since the main aquifer is overlain by sediments of relatively low permeability and applied water in excess of consumptive use is prevented, for the most part, from returning to the ground water formation for possible re-use. Irrecoverable losses also occur in the urban area in the vicinity of Del Mar where sewage is discharged directly to the ocean. For this area, water requirements were assumed equal to the total amount of applied water.

The present mean seasonal water requirement of San Dieguito River watershed is estimated to be about 17,700 acre-feet. Estimates of present mean seasonal water requirements for hydrologic units and subunits within the watershed are presented in Table 13.

TABLE 13

PRESENT MEAN SEASONAL WATER REQUIREMENTS IN SAN DIECUITO RIVER WATERSHED FOR 1956-57

In Acre-Feet

Hydrologic unit and subunit	0		mean seasonal requirement
Inland Unit Sutherland Subunit Pamo Subunit Ramona Subunit Guejito Subunit Roden Subunit		30* 250 1,840 0 50	
Subtotal			2,170
Central Unit San Pasqual Subunit Hodges Subunit		4,410 6,500*	
Subtotal			10,910
Coastal Unit			4,590
TOTAL			17,670

^{*} Does not include evaporation from Hodges and Sutherland Reservoirs.

Probable Ultimate Water Requirement

It is assumed that, under ultimate conditions of land and water use, water applied in excess of requirements for consumptive use would appear as subsurface and surface flow from areas of higher elevation in the eastern portion of the watershed to the lower valley areas diminished by the estimated magnitude of nonbeneficial channel losses. Net return flow, defined as that portion of return flow available for re-use in other areas, originating in Santa Maria Valley would augment the water supply of San Pasqual Valley. A portion of this flow together with return flow from other

irrigated areas in the watershed would eventually enter Lake Hodges for diversion to service areas of the City of San Diego, Del Mar Utilities, or San Dieguito and Santa Fe Irrigation Districts. Similarly, net return flow from Santa Ysabel Valley would enter Sutherland Reservoir for diversion through existing conveyance facilities to San Vicente Reservoir. It was further assumed that sewage from the urban area within the watershed south of the City of Escondido would be exported for disposal elsewhere and that sewage from the Coastal Unit would discharge into the ocean.

The probable ultimate mean seasonal water requirement in San Dieguito River watershed is estimated to be 156,100 acre-feet. Estimates of mean seasonal water requirements within hydrologic units and subunits under probable ultimate conditions of development are set forth in Table 14.

TABLE 14

PROBABLE ULITIMATE MEAN SEASONAL WATER
REQUIREMENTS IN SAN DIEGUITO RIVER WATERSHED

In Acre-Feet

Hydrologic unit	:	Probable ultimate mean	
and subunit	:	seasonal water requirement	
Inland Unit Sutherland Subunit Pamo Subunit Ramona Subunit Guejito Subunit Rođen Subunit		19,400 14,000 34,300 12,600 4,500	
Subtotal		84,800	
Central Unit San Pasqual Subunit Hodges Subunit		16,000 29,000	
Subtotal		45,000	
Coastal Unit		26,300	
TOTAL		156,100	
TOTAL			

In addition to the previously discussed water requirements, water is used within San Dieguito River watershed for recreational purposes. This use is considered nonconsumptive in nature. Fresh water fishing and duck hunting are permitted at Sutherland and Hodges Reservoirs except when water levels are low. Fishing permits numbering 7,175 and 503 hunting permits were issued by the City of San Diego at Sutherland Reservoir in 1956-57. Hodges Reservoir has been closed for recreational purposes since 1952-53 due to low storage levels. In 1952-53, 28,911 fishing permits were issued at that reservoir. Presumably, reservoirs constructed in the future for storage of water in San Dieguito River watershed will also provide facil—ities for recreation.

Since the use of reservoirs for recreational purposes is incidental to its use for conservation, such recreational use is not considered
in evaluating present and ultimate water requirements of the watershed.

Supplemental Water Requirements Within San Dieguito River Watershed

Supplemental water requirements represent the difference between present or probable ultimate water requirements and the presently developed and available water supplies. Supplemental water requirements in San Dieguito River watershed will be influenced in the future by changes in water requirements accompanying changes in agricultural and urban and suburban development.

Present Supplemental Water Requirements

Yield of the presently developed water supply was previously discussed and an estimate of the quantity has been given in Table 9. Except for the San Dieguito Basin, presently subject to overdraft conditions, the present mean seasonal water requirement within hydrologic units of the watershed is satisfied by the presently developed water supplies, and no supplemental water supplies are presently required. The present mean seasonal supplemental water requirement in San Dieguito Basin is estimated to average about 800 acre-feet.

Probable Ultimate Supplemental Water Requirements

It is estimated that water requirements under probable ultimate conditions of land use will exceed the presently available supply in all areas of the watershed except San Pasqual Basin. However, San Pasqual Subunit, comprised of San Pasqual Basin and adjacent hill areas, will have a probable ultimate supplemental water requirement of 11,600 acre-feet. Supplemental water requirements under ultimate conditions are estimated to total 136,600 acre-feet per season for the entire watershed. Probable ultimate mean seasonal supplemental water requirements in San Dieguito River watershed for each of the hydrologic units and subunits are presented in Table 15.

TABLE 15

PROBABLE ULTIMATE MEAN SEASONAL SUPPLEMENTAL WATER REQUIREMENTS OF SAN DIEGUITO RIVER WATERSHED

In Acre-Feet

Hydrologic unit and subunit	Probable ultimate mean seasonal water requirement	Presently veloped y available use with watershe	field : mean seasonal for : supplemental din : water
Inland Unit Sutherland Subunit Pamo Subunit Ramona Subunit Guejito Subunit Roden Subunit	19,400 14,000 34,300 12,600 4,500	30 250 1,840	19,370 13,750 32,460 12,600 4,450
Subtotals	84,800	2,170	82,630
Central Unit San Pasqual Subunit Hodges Subunit	16,000 29,000	4,490 <u>7,170</u>	11,510 21,830
Subtotals	45,000	11,660	33,340
Coastal Unit	26,300	5,670	20,630
TOTALS	156,100	19,500	136,600

^{*} The first barrel of the Second San Diego Aqueduct, now under construction, was assumed to be a presently developed facility for the purpose of computing ultimate supplemental water requirements.

The ultimate supplemental water requirements can be partially satisfied by increased development of local surface and ground water supplies, but a substantial increase in imports from sources outside the watershed will also be required. Possible means by which supplemental supplies can be developed are discussed in Chapter IV, "Plans for Water Development". Supplemental requirements would be reduced in areas inundated by construction of potential dams and reservoirs.

Water Requirements of the City of San Diego

As discussed in the foregoing portions of this report, the City of San Diego owns and operates Hodges and Sutherland Reservoirs in the San Dieguito River watershed. These facilities were constructed, and other water developments are planned, for the primary purpose of exporting water from the watershed to satisfy present and probable future water requirements of the City of San Diego. A discussion of present and future water requirements of the City of San Diego is presented in the following portion of this chapter.

Present Water Requirements of the City of San Diego

The City of San Diego comprised 123,500 acres in January, 1959, and extends from the coast to an elevation of approximately 800 feet. Since about 1940, the City has experienced a remarkable growth, increasing in population from 203,000 in 1940 to about 494,000 in 1957. The increase in population has been accompanied by marked industrial expansion, principally in the aircraft, electronic equipment, instrument, and plastic industries.

The changing industrial pattern and the increasing use of automatic household appliances requiring large volumes of water have been reflected in rates of per capita water consumption. The City of San Diego reports an increase in per capita use from approximately 100 gallons per day in 1941-42 to 129 gallons per day in 1956-57.

As a result of the increase in population and in the unit use of water, water consumption of the City of San Diego has increased from approximately 28,000 acre-feet in 1940-41 to 71,250 acre-feet in 1956-57.

Proposed annexations will increase the area of the City of San Diego from 123,500 acres in January, 1959, to an estimated 184,000 acres in the year 2000. Population is expected to increase from the present one-half million persons to approximately 1,450,000.

The City of San Diego Water Department has predicted that the water requirement of the City in the year 2000 will be in the order of 318,000 acre-feet, based on population projections by the City Planning Department and values of per capita water use determined in connection with the studies of alternative Feather River Project aqueduct routes to San Diego and presented in State Department of Water Resources Bulletin No. 61. City of San Diego estimates of future water requirements within the City's three water service areas are presented in Table 16. Location of the future service areas is shown on Plate 12.

TABLE 16

PROBABLE MEAN SEASONAL FUTURE WATER REQUIREMENTS OF CITY OF SAN DIEGO^a

-				17			
In	n	000	۵	·Hi	0	0	т.
	n	\cup_{\perp}	C	Т.	\sim	$\overline{}$	v

37	0	Service area		* m-+-7
Year	: Miramar	: Alvarado	: Lower Otay	Total
1960	16,900	57,300	15,200	89,400
1970	25,700	87,700	16,900	130,300
1980	55,200	115,400	21,400	192,000
1990 ^b	95,800	131,200	28,100	255,100
2000	136,400	147,100	34,700	318,200

a. Values estimated by City of San Diego Water Department unless otherwise noted.

b. Values derived by State Department of Water Resources.

Supplemental Water Requirements of the City of San Diego

Present Supplemental Water Requirements of the City of San Diego

Supplemental water requirements have been defined as the difference between water requirements and the presently available water supply, comprising yields from surface and ground water developments and imported supplies. Present water requirements of the City of San Diego far exceed the yield of local supplies, but under present conditions the deficiency is satisfied by importation of Colorado River water through the existing San Diego Aqueduct. Importation of Colorado River water in 1956-57 for use within the City of San Diego amounted to 83,551 acre-feet, or 57.5 per cent of the total deliveries to members of the San Diego County Water Authority. Since water requirements in excess of local supplies are currently met by purchase of Colorado River water, no present supplemental water requirement exists within the City of San Diego.

Purchases of Colorado River water by the City of San Diego and other members of the San Diego County Water Authority presently exceed their entitlement to this supply. When other member agencies of The Metropolitan Water District of Southern California purchase larger amounts of Colorado River water, the City's supply from this source will be reduced.

Probable Future Supplemental Water Requirements of the City of San Diego

As the requirement for water within the City of San Diego increases in the future, it is probable that the City will develop water resources within San Diego County to which it has, or will have, rights. It can also be anticipated that the City of San Diego will purchase increasing amounts of

Colorado River water, as limited by the City's proportionate share of imported supplies, and imported northern California water as these supplies become available. The proportional share of the City of San Diego to imported water in 1956-57 was about 98,000 acre-feet from the existing aqueduct.

Since the first barrel of the Second San Diego Aqueduct is under construction, it was assumed to be a presently developed facility for purposes of computing future supplemental water requirements even though water will probably not be delivered through this facility until 1960. The imported supply available to the City of San Diego was, therefore, taken as the City's estimated proportional right to purchase water from the San Diego County Water Authority. This right of the City of San Diego to imported water based on their estimated 1960 proportional share would be 206,000 acre-feet. The City estimates the presently developed yield from City surface reservoirs to be 14,700 acre-feet, providing a total mean seasonal present supply to the City of San Diego of 250,700 acre-feet upon completion of the first barrel of the Second San Diego Aqueduct, as shown on Plate 13 and in Table 17.

The presently developed yield from City reservoirs was reevaluated by this Department and found to be somewhat less than the yield
which was estimated by the City and indicated on Plate 13 and in Table 17.
The yield, as revised, is now estimated to be approximately 36,400 acrefeet per season, as set forth in Table L-l of Appendix L. Using the
revised estimate of yield from the City reservoirs, the total mean seasonal present supply to the City is estimated to be 244,400 acre-feet,
including imported water.

TABLE 17

YIELD OF PRESENTLY DEVELOPED WATER SUPPLY OF CITY OF SAN DIEGO

In Acre-Feet

Reservoir	safe y local	easonal ield of water ply* : Total	:Proportional : :right of City: :of San Diego : : to imported : :water in 1960:	Total supply
Miramar Service Area Hodges	3,360	3,360		
Alvarado Service Area Sutherland San Vicente El Capitan	8,960 5,940 11,200	26,100		
Lower Otay Service Area Morena Barrett Otay	5,600 5,380 4,260	15,240	00-70-70-70-70-70-70-70-70-70-70-70-70-7	
TOTALS		44,700	206,000	250,700

^{*} Values estimated by City of San Diego Water Department. Values as determined by this Department are presented in Table L-l of Appendix L.

It is estimated that by 1975 the water requirement within the City will be equal to the presently developed local supply plus the City's proportional right to waters from the San Diego County Water Authority and that supplemental supplies would be needed after that date. The City's proportional right to waters from the Authority will decrease in the future as the remaining portion of San Diego County develops and increases in assessed valuation at a more rapid rate than the City. This condition is depicted graphically on Plate 13, while future mean seasonal supplemental water requirements are presented in Table 18. Estimates of supplemental water requirements presented in Table 18 are based on the City's estimate of the presently developed yield from City reservoirs and does not reflect the afore-mentioned reevaluation of reservoir yield by this Department.

TABLE 18

ESTIMATED MEAN SEASONAL SUPPLEMENTAL WATER REQUIREMENTS OF CITY OF SAN DIEGO®

In Acre-Feet

Year		ble future me irements of C servic			:Total avail :able water :supply of	
0	Miramar	: Alvarado :	Lower Otay	: Total	:City of San : Diegob	supplemental water requirements
1960	16,900	57,300	15,200	89,400	250,700	0
1970	25,700	87,700	16,900	130,300	194,800	0
1980	55,200	115,400	21,400	192,000	138,300	53,700
1990	95,800	131,200	28,100	255,100	С	С
2000	136,400	147,100	34,700	318,200	С	c

- a. Values estimated by City of San Diego Water Department.
- b. Includes estimated proportional share of imported waters from the San Diego County Water Authority with First and Second San Diego Aqueducts in operation. Assumes mean seasonal safe yield of local water supply to be 14,700 acre-feet, as shown in Table 17, rather than 36,400 acre-feet, as estimated by this Department and presented in Table L-1 of Appendix L.
- c. Estimates of proportional share of imported water not furnished by City of San Diego.

CHAPTER IV. PLANS FOR WATER DEVELOPMENT

ently developed water supplies in the San Dieguito River watershed, including imported San Luis Rey River and Colorado River water, exceeds the present water requirements of the watershed. This condition, however, will change in future years. As discussed in Chapter III, a supplemental water requirement will exist in all areas of the watershed, except San Pasqual Basin, under ultimate conditions of land use. The probable ultimate mean seasonal supplemental water requirement in the San Dieguito River watershed of 136,600 acrefeet per season, will require that imported supplies be made available.

As a result of the large future demands for water, it may be expected that the water resources of the San Dieguito River will undergo further development for local use or for use of the City of San Diego. The City has a large financial investment in lands at dam and reservoir sites in the watershed and has filed applications with the State of California to appropriate 50 second-feet and store 397,000 acre-feet of water of the San Dieguito River.

Plans for importing water to the watershed and developing local water resources are discussed in this chapter, including a description of Feather River and Delta Diversion Projects studies, the Second San Diego Aqueduct, and features of The California Water Plan in San Diego County and a discussion of possible management of major ground water basins for greater yield. Comparisons of plans, and combinations thereof, are presented in Chapter VI.

Plans for Importation of Water Supplies

Although importation of San Luis Rey River water to the San Dieguito
River watershed may increase somewhat when the amount in storage in Lake Henshaw

is increased during years of above-normal runoff, the only significant increase in imports expected to occur in the future is that which will be furnished through the facilities of the San Diego County Water Authority. It is further expected that the facilities of the Authority will be utilized for importing water made available through units of The California Water Plan when such a supply becomes available.

In view of the future large supplemental water requirements in San Diego County which must be met by imported supplies, it is contemplated that several aqueducts will be constructed to implement this importation. Prospective plans for importation are described in Department of Water Resources Bulletin No. 3, "The California Water Plan", dated May, 1957, and include the Second San Diego, Barona, and San Diego High-Line Aqueducts as well as the Feather River and Delta Diversion Projects, the initial units of The California Water Plan.

Feather River and Delita Diversion Projects

These projects were reported upon by the former Division of Water Resources in 1951. They were planned to meet both the immediate need for additional water in the central and southern portions of the State and the critical need for flood control on the Feather River. The projects were originally outlined in State Water Resources Board "Report on Feasibility of the Feather River Project and Sacramento-San Joaquin Delta Diversion Projects Proposed as Features of The California Water Plan", May, 1951. The plan included an aqueduct to southern California with its terminus in San Diego County at Horsethief Canyon, above Barrett Reservoir. The projects outlined in the plan were authorized by the Legislature in 1951, by Chapter 1441, Statutes of 1951.

Further studies of the projects were continued by the Division of Water Resources until 1955, at which time a report entitled "Program"

for Financing and Constructing the Feather River Project as the Initial Unit of The California Water Plan[®], dated May, 1955, was submitted to the Legislature. It was concluded in this report that the project was engineeringly and financially feasible, and it was recommended that the Legislature appropriate funds to initiate its construction. The May, 1955, report also included proposals for alternative aqueduct routes to southern California.

The 1955 Legislature secured the services of the Bechtel Corporation to review the State's 1955 report. The results of this review generally confirmed the conclusion that the project was engineeringly and financially feasible.

The Legislature, in 1956, reauthorized the Feather River Project in accordance with the 1955 report. The Legislature also appropriated \$200,000 for surveys of alternative Feather River Project aqueduct routes to San Diego County. That investigation was initiated in May, 1956, and results of the studies were published in Department of Water Resources Bulletin No. 61 entitled "Feather River Project-Investigation of Alternative Aqueduct Routes to San Diego County", dated March, 1957. In addition to presenting conclusions as to the location, and recommendations as to the capacity, of an aqueduct to San Diego County, Bulletin No. 61 contains estimates of probable future population and irrigated area, and attendant demands for water in southwestern Riverside County and the coastal portion of San Diego County.

In view of the critical water problem in San Diego County, it was assumed in these alternative route investigations that aqueduct facilities to serve surplus northern California water to San Diego County, must,

in the interim until such water is available, be capable of serving presently surplus Colorado River water available at the facilities of The Metropolitan Water District of Southern California near San Jacinto.

It was recommended in Bulletin No. 61 that:

- "1. In view of the estimates of future water requirements in San Diego and southwestern Riverside Counties and economic analyses relative to initial aqueduct capacity, presented in this report, immediate steps be taken to construct the proposed San Diego Aqueduct with a capacity varying from 1,000 to 884 second-feet in the canal section, and a capacity varying from 432 to 98 second-feet in the pipe line section.
- "2. Responsible local agencies give continuing support to immediate construction of the Feather River Project and to future units of The California Water Plan which will be needed for satisfaction of forecast water requirements in the South Coastal Area including San Diego County."

The Metropolitan Water District of Southern California and the San Diego County Water Authority, a member agency of the District, are currently constructing the Second San Diego Aqueduct along a route generally similar to that recommended in Bulletin No. 61 as the most feasible.

In addition to studies of alternative aqueduct routes to San
Diego County, the Department of Water Resources conducted an investigation
of alternative aqueduct routes leading from the San Joaquin Valley to
southern California. The investigation was reported upon in Department
of Water Resources Bulletin No. 78, entitled "Preliminary Summary Report
on Investigation of Alternative Aqueduct Systems to Serve Southern
California", published in preliminary form in February, 1959. Final publication is planned to be made shortly. The California Legislature of
1959, by Chapter 2043, reauthorized the Feather River and Delta Diversion
Projects as modified by findings and recommendations contained in
Bulletin No. 78.

As heretofore stated, The Metropolitan Water District of Southern California and the San Diego County Water Authority are proceeding with construction of the Second San Diego Aqueduct along the route generally recommended in Bulletin No. 61.

The Second San Diego Aqueduct starts from the Colorado River Aqueduct near the west portal of the San Jacinto Tunnel. The first portion of the aqueduct is in canal and will have a capacity of 1,000 second-feet. The pipe line portion will have a capacity of 250 second-feet at the northerly end and will decrease to 144 second-feet in the southernmost section between Sweetwater and Otay Reservoirs. The canal section will have the same capacity, but the pipe line section will be smaller than that recommended in Bulletin No. 61. Additional barrels may be constructed in the future along the pipe line portion of the aqueduct as the need arises.

The supply to be made available to San Diego County through the Second San Diego Aqueduct, amounting to 181,000 acre-feet per year, coupled with the 141,500 acre-feet per year delivered through the existing San Diego Aqueduct, will provide a total imported supply of 322,500 acre-feet per year to San Diego County. It is anticipated that construction of the first barrel of the Second San Diego Aqueduct will be completed in 1960.

Barona Aqueduct

As described in The California Water Plan, the Barona Aqueduct would connect with major conveyance facilities from northern Calfironia at Devil Canyon, about seven miles northwest of the City of San Bernardino, and would extend southerly to a connection with the Colorado River Aqueduct at the westerly portal of the San Jacinto Tunnel. From the San Jacinto

Junction, the Barona Aqueduct would extend southerly, to the east of and generally paralleling the existing San Diego Aqueduct, crossing San Pasqual Valley at approximately the confluence of Guejito and Santa Ysabel Creeks.

Barona Aqueduct would terminate in Barona Reservoir to be located on Barona Creek, a tributary of San Vicente Creek which, in turn, is a tributary to the San Diego River.

It was contemplated in Bulletin No. 3 that Barona Aqueduct would have a maximum capacity of 1,400 second-feet south of its connection with the Colorado River Aqueduct and would provide a seasonal supply of 757,000 acre-feet for San Jacinto Valley and San Diego County. It was further anticipated that Barona Aqueduct, the existing San Diego Aqueduct, and the Second San Diego Aqueduct would be operated as an integrated system. Direct water service would be provided to lands along the Barona Aqueduct, including areas within San Dieguito River watershed. Since the Second San Diego Aqueduct is being constructed to a larger capacity than was envisioned in Bulletin No. 3, it is expected that the capacity of the Barona Aqueduct would be less than was previously estimated and that construction of this aqueduct would be delayed for many years.

San Diego High-Line Aqueduct

The San Diego High-Line Aqueduct would connect with aqueducts from northern California at Cedar Springs Forebay at the north edge of the San Bernardino Mountains in San Bernardino County. The aqueduct would traverse the San Bernardino Mountains by tunnel and cross San Gorgonio Pass in a siphon between the cities of Beaumont and Banning. From this point, the San Diego High-Line Aqueduct would extend southerly and cross Santa Ysabel Creek about one mile above Sutherland Reservoir, terminating at Horsethief Canyon, a tributary of Pine Valley Creek, which is in turn a tributary of Cottonwood Creek above Barrett Reservoir. It was contemplated in

Bulletin No. 3 that the San Diego High-Line Aqueduct would decrease from 1,300 second-feet at its northern terminus to 180 second-feet at Horse-thief Canyon. Since the adopted capacity of the Second San Diego Aqueduct is larger than was anticipated, it is now expected that the capacity of the San Diego High-Line Aqueduct will be less than was previously estimated and that construction of this facility will be delayed for many years. It is contemplated that the San Diego High-Line Aqueduct will serve only lands lying at the higher elevations where development and attendant water demands will occur at a lesser rate than in the remaining portions of San Diego County. Location of the Second San Diego Aqueduct and other aqueducts and reservoirs included in The California Water Plan which affect the water supply to San Dieguito River watershed is illustrated on Plate 14.

Plans for Local Conservation Development

Outflow to the ocean, amounting to an average of about 26,300 acre-feet per season for the period 1914-15 through 1956-57, under present conditions of land use and water supply development, indicates that undeveloped water supplies are present in San Dieguito River watershed. Not all of the flow to the ocean can be conserved, of course, due to economic limits of reservoir storage capacities and the high rate of evaporation prevailing in San Diego County. A portion of the waste to the ocean, however, could be conserved through direct diversion of surface runoff, increased development of ground water supplies, and storage of runoff in surface reservoirs.

A factor which must be recognized in considering the construction of projects discussed herein is the probable occurrence of droughts more severe than those within the period of record. The prospective recurrence of such periods lend some uncertainties to the yield estimates of any proposed water conservation project in this part of California. The larger the reservoir, with the attendant longer carry-over period, the greater is the inherent uncertainty as to the probable yield therefrom. Another factor which should be taken into consideration, is the possible lapse of time after reservoir construction before any benefit will be realized. If a reservoir were to be constructed at the beginning of a long drought period, little value would be received until the ensuing wet period.

For these reasons, it is apparent that planning for local water resources development must be initiated many years in advance of the actual need.

Because of the intermittent character of runoff in many streams within the watershed and the wide fluctuation in magnitude of discharge, it is concluded that significant additional development of the water resources by direct diversion from streams is infeasible.

Plans for projects for water conservation development in the San Dieguito River watershed are preliminary in nature. In particular, they are not meant to be compared to plans and specifications for definite project construction. Project costs for report purposes are based on approximate quantities estimated from preliminary designs and estimated unit prices based on recent bids on projects similar to those under consideration or from manufacturer's price lists. The costs are considered to be representative of those prevailing in the spring of 1958.

Estimates of capital costs include costs of construction, stream diversion during construction, acquisition of lands, easements, rights of way, and relocation of utilities and highways; and include an allowance of 15 per cent of capital cost for contingencies. An allowance of 10 per cent for administration and engineering was also included except for acquisition of lands and improvements. Interest during one-half of the estimated construction period at 4 per cent per annum is also included as part of the capital cost.

Estimates of annual project costs include interest on the capital investment at 3 1/2 per cent per annum, amortization over a 40-year period on a 3 1/2 per cent sinking fund basis, operation and maintenance costs, and costs of electrical energy required for pumping, if applicable.

Planned Operation of Ground Water Basins

With the exception of the alluvial San Pasqual and San Dieguito Basins, ground water bodies within San Dieguito River watershed are located, for the most part, in the less permeable hilly areas of decomposed granitics. The majority of wells located in the residuum produce only small quantities of water. In order to achieve large productive capacity, it is usually necessary to construct horizontal laterals from the main vertical well.

In view of the relatively low permeability of the decomposed granitic residuum found in Ramona and Felicita Basins and other smaller ground water bodies, and considering the present withdrawals from these basins and the cost of new well construction, significant additional development of these ground water basins is not considered to be practicable.

As mentioned heretofore, ground water levels in San Dieguito Basin were as much as 40 feet below sea level in some areas in the fall of 1957, and an overdraft condition is believed to exist. In view of these conditions and the threat of sea-water intrusion, a reduction in the present withdrawal of ground water in this basin appears desirable.

The adjacent San Pasqual and Lake Hodges Basins were previously described in Chapter II. For the purposes of this report, San Pasqual Basin and the main valley portion of Lake Hodges Basin are considered together as a unit and are hereafter referred to as the San Pasqual-Main Lake Hodges Basin. This basin contains an appreciable quantity of undeveloped water and the average seasonal supply to the unit will exceed its seasonal water requirement, even under ultimate conditions of land use. The City of San Diego has indicated its interest in developing additional ground water in San Pasqual-Main Lake Hodges Basin and has purchased most of the land in the basin lying below an elevation of 395 feet. Development of this supply would not be subject to the evaporation losses associated with surface reservoir developments, but it would entail purchase of additional lands in and adjacent to the basin or would require a cooperative mutually beneficial undertaking between the City of San Diego and all other overlying land owners in the basin.

Since planned operation of the basin would produce a significant amount of new yield at a much smaller financial investment than would be required for a surface development, further development of the ground water reservoir was evaluated as part of this investigation. Conjunctive operation of San Pasqual—Main Lake Hodges Basin with surface storage was also considered and is discussed in a succeeding portion of this chapter.

In determining amounts of new and total yields from San Pasqual-Main Lake Hodges Basin for various usable storage capacities, the following criteria were used:

- l. Mean seasonal net extraction of water from the ground water basin does not exceed mean seasonal replenishment to the basin.
- 2. Water levels are not so lowered as to cause harmful impairment of the quality of the ground water by intrusion of other waters of undesirable quality, or by accumulation and concentration of degradants or pollutants.
- 3. Water levels are not so lowered as to imperil the economy of the use of ground water by excessive costs of pumping from the basin or by exclusion of the users from a supply therefrom.

Mean seasonal net yield and replenishment were determined for various usable storage capacities of San Pasqual-Main Lake Hodges Basin by solving for the items of supply and disposal in the hydrologic equation.

Water quality studies indicated that no degradation or pollution of the ground water supply would accrue from lowering the ground water levels.

From an analysis of historic ground water levels, considering depths to nonwater-bearing material underlying the basin, anticipated drawdown from pumping wells, and probable costs of well installations and pumping, it is assumed that ground water levels could be lowered at the end of a drought period to a maximum average depth throughout San Pasqual-Main Lake Hodges Basin of approximately 71 feet below the ground surface without precipitating an adverse quodition. Depths to static ground water at this maximum basin depletion would vary from about 50 feet in Main Lake Hodges Basin to approximately 100 feet in the eastern portion of San Pasqual Basin.

Ground water levels would fluctuate widely during the period 1914-15 through 1956-57, with the average depth to ground water for the period being

approximately 25 feet, ranging from about 5 feet in Main Lake Hooges Basin to about 50 feet in the eastern portion of San Pasqual Basin.

A maximum average lowering of ground water levels of about 71 feet would result in a storage depletion of approximately 41,000 acre-feet, as shown on Plate 15. Assuming the operation of the basin to utilize the 41,000 acre-feet of storage space and assuming present land use and Sutherland Reser-voir in operation during the period 1914-15 through 1956-57, the estimated mean seasonal safe yield would be 6,000 acre-feet, or an increased yield of 2,800 acre-feet, over and above the present net withdrawals of 3,200 acre-feet, as depicted on Plate 15.

By applying the City of San Diego's average monthly distribution of seasonal demand to the 2,800 acre-feet of new yield and an average monthly distribution of seasonal agricultural demand to the 3,200 acre-feet of existing yield required to satisfy water requirements of overlying lands, the average maximum monthly net draft from San Pasqual-Main Lake Hodges Basin to meet these two demands was computed to be about 840 acre-feet, or about 14 second-feet continuous flow. The number and type of well installations and capacity of pumping equipment were based on this maximum monthly draft. If the entire 6,000 acre-feet of yield were conveyed to Lake Hodges and exported to the City of San Diego in accordance with the more uniform monthly distribution of urban demand, the maximum monthly draft would be only about 10 second-feet.

The estimate of cost for developing the maximum practicable yield from San Pasqual-Main Lake Hodges Basin includes the cost of drilling six 16-inch diameter gravel-packed wells, varying in depth from 60 feet near the western portion of the basin to 175 feet near the central portion of the basin. Wells would be supplied with suitable turbine pumps and motors capable of furnishing approximately 500 gallons per minute per well. Seven existing wells, estimated to range in capacity from about 400 gallons per minute to 850 gallons per minute, would also be employed.

Feeder pipe lines would connect the wells to distribution systems of overlying land users or to a city-cwned concrete-lined canal of trapezoidal section. The canal would increase in capacity from seven second-feet at the upper part of the basin to 14 second-feet near the middle of the basin. Capacity of the canal would remain the same from this point to its terminus at Lake Hodges, just west of Bernardo Mountain. Sizing of the canal would permit the entire yield to be withdrawn and diverted from the upper portion of San Pasqual-Main Lake Hodges Basin. Such a pumping pattern might be desirable if ground water levels in the lower end of the basin had been lowered substantially during a drought period and replenishment of the ground water supplies had been confined to the upper part of the basin. It is assumed that under these circumstances, increased extractions could be effected by use of certain of the numerous wells existing in the upper area of the basin.

Smaller yields can, of course, be developed in San Pasqual-Main Lake Hodges Basin with less lowering of ground water levels. Estimated mean seasonal safe yields for an average lowering of 30 feet and 50 feet are 3,200 acre-feet and 4,800 acre-feet, respectively. The relationship between ground water storage depletion, yield, and average depth to ground water in the basin is illustrated on Plate 15. A general description of facilities for developing an additional water supply from San Pasqual-Main Lake Hodges Basin, and capital and annual costs of the project, are presented in Table 19. General location of the wells, pipe lines, and canal is shown on Plate 16. Detailed cost estimates are contained in Appendix K.

TABLE 19

GENERAL FEATURES OF WELLS, PUMPING PLANTS, AND
CONVEYANCE FACILITIES AT SAN PASQUAL-MAIN LAKE HODGES BASIN

	8	d water stora	
	: 13,700	: 27,000	: 41,000
Depth to Ground Water and Yield			
Maximum average depth to ground water, in feet New seasonal yield, in acre-feet	30 0	50 1,600	71 2,800
Total mean seasonal safe yield, in acre-feet	3,200	4,800	6,000
Project Facilities	7,200	Д,000	0,000
Project Pacificles			
Number of primary 16-inch diameter gravel-packed wells to be constructed		2	6
Number of primary existing wells to be used Average depth of new wells, in feet	e 7 	7 157	7 127
Average yield per new well, in gallons per minute	5	330	290
Average yield per existing well, in gallons per minute Motor horsepower required to operate	290 Use exist	330	290
new pumps	ing motor		20,25,30,40
Length of primary pipe line from wells to canal for basin-wide pumping pattern, in feet 8-inch diameter 10-inch diameter 12-inch diameter	1,100 8,300 1,300	2,500 8,400 2,900	5,100 14,100 4,900
Length of standby pipe line from wells to canal for upper basin pumping pattern, in feet 6-inch diameter 8-inch diameter 10-inch diameter 12-inch diameter Minimum capacity of concrete-lined	4,000 5,100 4,700 3,000	4,000 5,100 4,700 3,000	4,000 5,700 5,600 3,500
canal in upper basin, in second-feet Maximum capacity of concrete-lined canal in upper basin and to Lake Hoo		5.6	7.0
in second-feet	7.5	11.2	14.0

GENERAL FEATURES OF WELLS, PUMPING PLANTS, AND CONVEYANCE FACILITIES AT SAN PASQUAL-MAIN LAKE HODGES BASIN (continued)

	:Usable ground water storage capacity : in acre-feet : 13,700 : 27,000 : 41,000			
Capital Costs				
Ground water development ^a Per acre-foot of storage Per acre-foot of total safe yield ^b	\$5,966,800 436 1,865	\$6,043,500 224 1,259	\$6,163,700 150 1,027	
Annual Costs				
Ground water development ^a Per acre-foot of storage Per acre-foot of total safe yield ^b	298,000 22 93	306,300 11 64	316,100 8 53	

a. Includes the estimated costs of lands and improvements which would probably be required for basin operation.

b. Assuming the total safe yield is developed and conveyed to Hodges Reservoir for use by the City of San Diego.

Potential Surface Storage Developments

During the studies which led to the publishing of Bulletin No. 55 and Bulletin No. 3, the engineering feasibility of constructing dams at the following sites for conservation of local water or regulation of imported water was investigated:

Dam site	Location
Santa Ysabel	On Santa Ysabel Creek about 11 miles northeast of Ramona
Pamo "A", "B", and "C"	On Santa Ysabel Creek about 4 miles north of Ramona
Santa Maria	On Santa Maria Creek about 5 miles northwest of Ramona
Guejito	On Guejito Creek about 5 miles northeast of Lake Wohlford Dam
San Pasqual "A" and "B"	On San Dieguito River about 4 miles southeast of City of Escondido
Super Hodges	On San Dieguito River about 6 miles southwest of City of Escondido

It was concluded from these analyses that a development at San Pasqual "B" site should be excluded from further consideration since it appeared much more costly than the San Pasqual "A" site, and that Santa Ysabel, Santa Maria, and Guejito sites should be considered only for regulation of imported water. Consequently, the investigation of surface storage developments, described herein, has been limited to an evaluation of projects at the Pamo "B" site, Super Hodges site, and San Pasqual "A" site, subsequently referred to as the San Pasqual site, and an evaluation of an enlarged San Vicente Reservoir and enlargment of Sutherland Reservoir by installation of spillway gates. Location of these sites of potential local water development is shown on Plates 14 and 17.

As previously mentioned, records of runoff for the drought period 1895-96 through 1904-05, used for safe yield studies presented in Bulletin No. 55, were not used in this investigation since it was found that the current drought period is critical with respect to safe yield determinations for reservoirs in San Diego County. Consequently it was necessary, in order to complete reservoir yield studies to estimate amounts of precipitation, evaporation, and runoff at Sutherland, Pamo "B", San Pasqual, and Super Hodges Reservoirs for the period 1914-15 through 1956-57. The yield studies assumed present conditions of ground water development except in the case of San Pasqual Reservoir, for which utilization of ground water in the San Pasqual Basin would be prevented by inundation of the reservoir lands or would be in accordance with a planned operation conducted coordinately with use of the surface reservoir.

Records and estimates of evaporation at Sutherland Dam and at other dam sites considered herein for the period 1936-37 through 1956-57 are presented in Appendix I.

Sutherland Reservoir and Dam With Spillway Gates. When Sutherland Dam was completed in 1954 by the City of San Diego, facilities were provided for the installation of 13-foot high radial-type spillway gates. If these gates were added, the gross storage capacity of Sutherland Reservoir would be increased from 29,680 acre-feet to 37,430 acre-feet and the reservoir area with water surface at the top of the gates would be enlarged from 560 acres to 640 acres.

Increasing the reservoir storage capacity would reduce the volume of spills, while evaporation losses would increase due to the enlargement in average surface area. An evaluation of the effect of these factors on reservoir yield reveals that the combined net safe seasonal yield of Sutherland and existing Hodges Reservoirs would be increased from 8,200 acre-feet

to 8,800 acre-feet if the gates were added and the reservoirs were operated coordinately during the 43-year period from 1914-15 through 1956-57, assuming present land and water use in San Pasqual-Main Lake Hodges Basin.

In order to reduce the volume of spill and waste to the ocean from Hodges Reservoir, it was concluded that on a combined safe yield basis the coordinated use of Hodges and Sutherland Reservoirs would be the most realistic operation and achieve the greatest reservoir yields. Such an operation could be easily effected since both reservoirs are owned and operated by the same agency. The reduction of loss by evaporation and by discharge to the ocean requires the maintenance of as much available storage capacity in Hodges Reservoir as possible.

However, the diversion capacity of the conveyance works from Hodges Dam limits the quantity by which the reservoir can be drawn down in any one month. Therefore, the operation selected for purposes of this investigation for existing surface storage developments assumes that the combined safe yield of the reservoir system would be applied first as a draft on Hodges Reservoir until the dead storage level was attained or the demand exceeded diversion capacity, and then the yield would be applied as a draft on Sutherland Reservoir. Diversions from Hodges Reservoir would take place when necessary in order to maintain dead storage level.

Under the combined safe yield operation, the annual system draft is the same every year, and the system draft for any particular month, based on average monthly distribution of seasonal urban demand by the City of San Diego, is the same in any year. However, drafts on the separate reservoirs would vary from month to month and year to year, depending on storage conditions.

City of San Diego operates Sutherland Reservoir on a secondary

yield basis, diverting water from Sutherland Reservoir to San Vicente Reservoir at the maximum rate permitted by conveyance capacity. Since such diversions over a long period would exceed the "safe" yield of the development, the reservoir would be depleted to dead storage during an extended drought period. Under a secondary yield operation, it is necessary to have a supplemental source of water available during such drought periods. In this case, the supplemental source is the San Diego Aqueduct. When and if the water requirements of the City of San Diego exceed the entitlement of the City to imported water through the facilities of the San Diego County Water Authority, it would no longer be safe to operate the reservoirs on a secondary yield basis.

If spillway gates were added to Sutherland Dam and the reservoir continued to be operated on a secondary yield basis, the average amount in storage, the reservoir surface area, accompanying evaporation losses, and the spills from the reservoir would all be less than that occurring under safe yield operation. It was determined that the seasonal secondary yield would be increased very little by the addition of spillway gates, although the safe yield would be substantially increased by such addition.

General features of Sutherland Reservoir and Dam equipped with spillway gates, the cost of these gates, and their effect on reservoir storage capacity, surface area, and safe yield are presented in Table 20.

GENERAL FEATURES OF SUTHERLAND DAM AND RESERVOIR WITH AND WITHOUT SPILLWAY GATES

Characteristics of Site

Drainage area -- 54 square miles

Estimated average seasonal runoff--14,000 acre-feet

Estimated average net seasonal depth of evaporation -- 2.6 feet

Estimated sedimentation--1,800 acre-feet, average for 40-year amortization period Elevation of stream bed, U.S.G.S. datum--1,912 feet

	Existing reservoir	Enlarged reservoir
Gross reservoir storage capacity, in acre-feet	29,680	37,430 ^a
Concrete Multi-arch Dam Crest elevation, in feet, U.S.G.S. datum Parapet wall, top elevation, in feet,	2,070	2,070
U.S.G.S. datum Crest length, in feet	2,074 1,020	2,074 1,020
Crest width, in feet Height of gates, in feet Height, spillway lip above stream bed, in feet	145	13 158 ^a
Freeboard between spillway lip and top of parapet, in feet	17	₄ a
Reservoir Surface area at spillway lip, in acres Net storage capacity at spillway lip, in acre-feet Type of spillway Spillway discharge capacity, in second-feet Type of outlet Additional safe seasonal yield to the City of San Diego from the system due to		640 ^a 35,630 ^a concrete chute ^b 37,000 ^b Two 36-inch diam. cast- iron pipes
spîllway gates, in acre-feet ^C Capital Costs	888	600
Addition of gates Per acre-foot of additional storage Per acre-foot of additional net safe yield	84 C) C)	\$243,500 31
from system	සා දස සා	406
Annual Costs Addition of gates Per acre-foot of additional net safe yield	8 . C (C)	\$ 12,400
from system		21

a. Based on full storage level at top of spillway gates.

b. Assumes two piers would be added to weir to accommodate gates.

c. System consists of Sutherland and Hodges Reservoir operated coordinately assuming present land and water use in San Pasqual-Main Lake Hodges Basin.

Sidered for Famo Dam are located within a specially reach of Santa Ysabel Creek, approximately one and one-half miles downstream from its confluence with Temescal Creek in Section 27, T. 12 S., R. 1 E., S. B. B. & M., as described in Bulletin No. 55. Dam site "A" is located near the west line of Section 27, with site "B" approximately three-quarters of a mile upstream from site "A". Site "C" is about 1,700 feet upstream from site "B" and approximately 800 feet west of the east line of Section 27.

It was necessary to select one of the sites to be evaluated on the basis of cost and reservoir yield compared with other proposed projects within the watershed. Consequently, preliminary construction quantities and costs for the earthfill and spillway for dams at each of the three sites were estimated for various alignments of axis and spillway location. A comparison of construction costs of the dams, considering spillway excavation, lining costs, haul distance, and stripping costs based on available geologic information, indicated that a dam at site "B" would entail a lesser capital expenditure than structures at the other sites for equivalent storage capacity. The results of previous geologic studies and reconnaissance surveys by geologists of the State Department of Water Resources in 1957 indicate that site "B" is suitable for an earthfill dam.

Stream bed elevation at Pamo "B" site is about 850 feet, United

States Geological Survey datum. The drainage area above the dam site

comprises 111 square miles, of which 57 square miles lie below Sutherland

Dam, located approximately 7 miles upstream. The tributary drainage area

between Sutherland Dam and Pamo "B" site produces an estimated mean natural

seasonal runoff of about 9,500 acre-feet for the 43-year period 1914-15

through 1956-57. If the present Sutherland Reservoir had existed during

this period, and had been operated coordinately with existing Hodges Reservoir

on a safe yield basis, in the manner previously discussed, it would have spilled every year except 1948, 1950, 1951, 1955, 1956, and 1957, providing an additional estimated mean seasonal runoff of about 11,500 acre-feet at Pamo "B" dam site. Estimated net seasonal depth of evaporation for this period at this reservoir site is 3.42 feet.

Designs of dams considered at Pamo "B" site are based on topographic maps at a scale of one inch equals 200 feet with a ten-foot contour interval.

Reservoir areas and capacities at various water surface elevations were estimated from topographic maps at a scale of one inch equals 400 feet with a ten-foot contour interval and are presented in Table 21. These maps were prepared for Bulletin No. 55 by Fairchild Aerial Surveys, Inc.

TABLE 21

AREAS AND CAPACITIES OF PAMO "B" RESERVOIR*

Water surface elevation, U.S.G.S. datum, in feet	Depth of water: at dam, in feet:	Water surface : area, :	Storage capacity, in acre-feet
850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1,000 1,010 1,020 1,030 1,037 1,050 1,064 1,070 1,079 1,090 1,100	10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 187 200 214 220 229 240 250	5 15 3l ₄ 80 115 182 233 290 351 l ₄ 25 509 593 687 781 889 1,050 1,186 1,322 1,125 1,619 1,865 1,956 2,090 2,255 2,378	30 132 376 944 1,917 3,400 5,477 8,095 11,302 15,183 19,856 25,370 31,769 39,105 47,452 57,147 68,326 80,866 90,000 110,258 135,000 146,133 163,400 188,385 211,551

^{*} Adapted from data shown in Bulletin No. 55.

One test pit was dug in 1913 and 13 core borings were made in 1914 at Pamo "B" site by Volcan Land and Water Company. The 45-foot deep test pit is located on the right abutment, 150 feet above stream bed, and is still available for inspection. Comments by Chester Marliave, consulting geologist, following his inspection of the site were presented in Bulletin No. 55 and are as follows:

"The granite here shows some hard outcrops in the channel section only, but this hard rock may not be continuous. The abutments are decomposed and deeply weathered. An earth type of dam seems to be the most suited for this location. A spillway could probably be constructed over either abutment beyond the ends of the dam. An outlet tunnel could well be constructed through the left abutment or placed in cut and cover along the left bank of the channel section."

Geologic information developed from previous studies and recent surveys by geologists of the State Department of Water Resources indicate that the Pamo "B" site is suitable for construction of earthfill dams up to a height of about 260 feet above stream bed. This height appears to be about the upper limit for the site from a topographic standpoint.

In view of the need for approaching complete development of the surplus water supplies within the watershed, and after a survey of topographic conditions, earthfill dam heights of 210 feet, 236 feet, and 250 feet from stream bed to dam crest were selected for yield and cost comparison analyses. These structures would provide gross reservoir storage capacities of 90,000 acre-feet, 135,000 acre-feet, and 163,400 acre-feet, respectively.

To determine the suitability of materials available near the site for use in an earthfill dam, three samples of impervious material and one sample of pervious material were collected from prospective borrow areas and tested to determine grain size distribution, plasticity, specific gravity, maximum density at optimum moisture, and permeability. Two impervious samples were also tested to determine the direct shear strength. Results of laboratory soil tests are presented in Appendix J.

posits indicate that the particle sizes were too uniform and that the deposits do not contain sufficient coarse material to provide stable fill slopes. Cost estimates are, therefore, based on random upstream and downstream sections containing a mixture of channel sediments and the coarser impervious materials secured by ripping the harder underlying formation in borrow areas adjacent to the stream and from spillway excavation. Soil tests further revealed that upstream and downstream slopes of 3:1 for all three dams at Pamo "B" site would be suitable. The impervious section for all three dams would have an upstream and downstream slope of 0.8:1.

Employment of semipervious random fill in the outer sections would necessitate the installation of gravel drains at the downstream face of the impervious section as a precautionary measure to control the path of leakage. The upstream face and downstream toe of all three dams would be protected against wave action and erosion from spillway discharges by rock riprap placed to a depth of three feet, normal to the slope. Crest widths would be 30 feet, comprising a 10-foot width for the impervious core and a 10-foot width each for the upstream and downstream random sections.

Materials suitable in quantity and quality for the impervious core and random sections of the largest dam considered can be secured within a distance of two and one-half miles upstream from the site. A site for a quarry to supply rock riprap is located approximately two miles upstream from the dam site, and this supply could be augmented with rock excavated during spillway construction.

Stripping estimates were based on the previously mentioned geologic investigations. Under the impervious core a depth of 22 feet of material would be stripped from the stream channel and 19 feet and 40 feet of soil and broken rock would be removed from the left and right abutment, respectively. Under the random sections of the dam, stripping of soil and broken rock to a depth of

eight feet would be necessary in the channel and from the right abutment, while depth of stripping from the left abutment would be approximately five feet.

Moderate grouting would probably be necessary to prevent leakage in the foundation and abutments.

The estimated peak flow at Pamo "B" dam site for a once-in-l00-year flood and a once-in-l,000-year flood is 67,200 second-feet and 124,000 second-feet, respectively. Reduction of a once-in-l00-year flood followed three days later with a once-in-l,000-year flood, for the various sizes of dam and reservoir considered at the Pamo "B" site, is indicated in the following tabulation:

Height of dam crest above stream bed, in feet	Gross reservoir storage capacity, in acre-feet	Peak inflow of a once-in- 100-year flood, in second-feet	Peak inflow of a once-in- 1,000-year flood, in second-feet	Peak spillway discharge, in second-feet	Maximum head on spillway, in feet
210	90,000	67,200	124,000	83,100	18
236	135,000	67,200	124,000	78,500	17
250	163,400	67,200	124,000	75,000	16

A five-foot residual freeboard between the maximum water surface at flood stage and the dam crest was assumed in the design of all three dams. The spillway would have a net crest length of 300 feet and would consist of a concrete-lined overpour chute with ogee weir control section. The spillway weir for all three dam heights considered would be located at the right abutment immediately adjacent to the dam fill, and the chute would convey spill across the right abutment to a well defined canyon tributary to Santa Ysabel Creek.

The outlet works intake structure would be a vertical reinforced concrete tower located at the upstream toe of each of the dams near the left abutment. Five butterfly valves would be located at vertical intervals within the tower to permit withdrawals from various elevations within the reservoir.

gate with trash rack would also be provided at the foot of the tower.

A steel pipe line, encased in concrete, would extend beneath the dams from the intake structure to a control valve house at the downstream toe of the dams. The conduit would be provided with cutoff collars within the impervious core section of the fill. The control valve house would be equipped with a bifurcation structure which would either permit discharge of water through a gate valve for sluicing directly into Santa Ysabel Creek or through a needle valve into a conduit for conveyance to areas outside the San Dieguito River watershed.

The City of San Diego owns Pamo "B" dam site and a portion of the reservoir area. The value of City lands and the cost of acquisition of privately-owned lands were estimated by appraisers of the State Department of Water Resources. It was estimated it would be necessary to acquire 19 parcels of privately-owned land, comprising approximately 1,860 acres, for construction of any of the three sizes of dam and reservoir considered. This was necessary since the smaller reservoir would destroy access to the improved area and acquisition of all private holdings would be advisable in view of the severance involved.

Approximately 13 miles of unpaved United States Forest Service access roads would be relocated for all three sizes of reservoir. The cost estimate also includes cost of constructing three miles of paved access road from the Ramona area to the dam.

Construction of the 210-foot and 236-foot high dams would require approximately two years, while about two and one-half years would be required to construct the 250-foot high structure. During the construction period,

Santa Ysabel Creek would be diverted through the outlet works during the low flow period, while winter flows would pass through an uncompleted portion of the fill in the channel section.

General features and capital and annual costs of three sizes of dam and reservoir at the Pamo "B" site on Santa Ysabel Creek are presented in Table 22, along with estimated values of additional and incremental safe yield. Detailed estimates of costs are contained in Appendix K. A plan, profile, and section of the 250-foot high dam are shown on Plate 18.

GENERAL FEATURES OF THREE SIZES OF DAM AND RESERVOIR AT THE PAMO "B" SITE ON SANTA YSABEL CREEK

Characteristics of Site

Drainage area -- 111.5 square miles

Drainage area below Sutherland Dam--57.5 square miles

Estimated average natural seasonal runoff below Sutherland Dam--9,500 acre-feet

Estimated average net seasonal depth of evaporation -- 3.42 feet

Estimated sedimentation--1,200 acre-feet, average for 40-year amortization period Flevation of stream bed, U.S.G.S. datum--850 feet

	: Gross res	ervoir storage	capacity,
	•	in acre-feet	
	: 90,000	: 135,000	: 163,400
Earthfill Dam			
Crest elevation, in feet, U.S.G.S.	1,060	1,086	1,100
Crest length, in feet	1,300	1,530	1,660
Crest width, in feet	30	30	30
Height, spillway lip above stream bed, in feet	7	214	229
Side slopes, upstream and downstream	3:1	3:1	3:1
Freeboard, above spillway lip, in feet	23	22	21
Volume of fill, in cubic yards	3,651,000	5,116,000	6,133,000
volume or itti, in capic yaras	3,071,000	7,110,000	0,100,000
70			
Reservoir	2 1.05	3 965	0 000
Surface area at spillway lip, in acres	1,425	1,865	2,090
Net storage capacity at spillway lip,	00 000	200 000	260 000
in acre-feet		133,800	
Type of spillway		eir with concr	
Spillway discharge capacity, in second-feet	83,100		
Type of outlet	42-inch	48-inch	54-inch
	diameter	diameter	diameter
	steel pipe	steel pipe	steel pipe
Additional safe seasonal yield to the			
City of San Diego from the system			
due to Pamo "B" Reservoir, in acre-feet ab	3,900	6,300	7,900
Incremental safe seasonal yield from	0,,	,,	• • • • • • • • • • • • • • • • • • • •
the system due to Pamo "B" Reservoir,			
in acre-feet ^{ab}	60 C3 C0	2,400	1,600
III 0020-2000		2,100	_,000

GENERAL FEATURES OF THREE SIZES OF DAM AND RESERVOIR AT THE PAMO "B" SITE ON SANTA YSABEL CREEK (continued)

	: Gross reservoir storage capacity, : in acre-feet : 90,000 : 135,000 : 163,400			
		. 157,000	. 205, 100	
Capital Costs Dam and reservoir Per acre-foot of storage Per acre-foot of additional net safe	\$7,526,700 84	\$9,213,300 68	\$10,922,000 67	
seasonal yield from the system	1,930	1,460	1,380	
Annual Costs				
Dam and reservoir Per acre-foot of additional net safe	\$ 363,900	\$ 446,100	\$ 527,800	
seasonal yield from the system	93	71	67	
Per acre-foot of incremental net safe seasonal yield from the system	en ce	34	51	

a. System consists of Sutherland Reservoir with spillway gates and Hodges and Pamo "B" Reservoirs operated coordinately assuming present land and water use in San Pasqual-Main Lake Hodges Basin.

b. Assumes releases from Pamo "B" Reservoir to maintain ground water levels in San Pasqual-Main Lake Hodges Basin equal to those which would have prevailed with Sutherland and Hodges Reservoirs operated coordinately on a combined safe yield basis.

Water diversed by conduit from Pamo "B" Reservoir would be conveyed to the Miramar Reservoir and Treatment Plant, proposed for construction in 1959, to serve the northern portion of the City of San Diego. The route chosen after inspection of available maps for the 24-mile long reinforced-concrete steel cylinder pipe line extends from Pamo "B" Reservoir, where the initial elevation would be 850 feet, along the south side of Santa Ysabel Canyon to a point near the west end of San Pasqual Valley. High pressure pipe would be used across Schoolhouse Canyon and Santa Maria Creek in Bandy Canyon.

From this point, the conduit extends in a southwesterly direction across Highland Valley, the existing San Diego Aqueduct, and Green Valley, and terminates in Miramar Reservoir at the spillway lip elevation of 710 feet. Miramar Reservoir site is located in Section 32, T. 14 S., R. 2 W., S. B. B. & M., about one mile east of U. S. Highway No. 395. Costs of high pressure pipe across Indian and Bernardo Canyons, Green Valley, and Los Penasquitos Canyon are included in the cost estimate.

Pipe line sizes and capacities vary in accordance with maximum draft for the three sizes of Pamo "B" Reservoir considered, operated coordinately with existing Hodges Reservoir and Sutherland Reservoir with spillway gates on a combined safe yield basis, as described in a succeeding portion of this chapter. Dead storage level in Pamo "B" Reservoir and water surface at the spillway lip in Miramar Reservoir were assumed for design purposes in determining the maximum head on the conduit. A pressure regulator at Pamo "B" Dam would prevent flows in the conduit from exceeding design capacities during high stages in Pamo "B" Reservoir. Sizes and capacities of the conduit for the various sizes of reservoir are presented in the following tabulation:

Gross reservoir storage capacity, in acre-feet	Inside diameter of conduit, in inches	Maximum design capacity of conduit, in second-feet
90,000	34	25
135,000	36	29
163,400	38	34

Design of conveyance facilities was preliminary in nature, and prior to preparation of construction plans and specifications, detailed field surveys, subsurface exploration, and soil testing will be required.

Presented in Appendix K are pertinent data with respect to the features and capital and annual costs of the conveyance facilities considered for Pamo "B" Dam and Reservoir. Alignment of the conduit between Pamo "B" and Miramar Reservoirs is shown on Plate 17.

Operation of Sutherland Reservoir would affect the yield from Pamo
"B" Reservoir, which in turn would modify yields from San Pasqual ground water
basin and Hodges Reservoir. In order to reduce the volume of spill and waste
to the ocean from Hodges Reservoir, it was concluded that the coordinated use
of all reservoirs on a combined safe yield basis would be the most realistic
operation and achieve the greatest system yield. To reduce the discharge to
the ocean from the San Dieguito River to the greatest practicable degree
requires the maintenance of as much available storage capacity in Hodges
Reservoir as possible.

The proposed operation of existing surface storage developments and the Pamo "B" Reservoir assumes that the combined safe yield of the reservoir system would be applied first as a draft on Hodges Reservoir until either the dead storage level was attained or the demand exceeded diversion capacity,

and then the combined yield would be applied as a draft on Sutherland and Pamo "B" Reservoirs in accordance with a balanced storage concept.

Diversions from Hodges Reservoir would take place wherever necessary to maintain dead storage level.

The balanced storage concept is defined as the reservoir operation under which available reservoir storage capacity in the system is maintained in proportion to the mean seasonal runoff above the dam. Use of this criterion reduces the possibility of one reservoir in a system spilling, especially one located at a lower elevation, while storage space exists in other reservoirs.

Under the combined safe yield operation, the annual system draft is the same every year, and the system draft for any particular month is based on average monthly distribution of seasonal urban demand by the City of San Diego and is the same as the system draft for that month in any year. However, drafts on individual reservoirs would vary from month to month and year to year, depending on storage conditions. The safe system yield for each of the three sizes of reservoir at the Pamo "B" site was determined by electronic machine computing methods. The results of the operation study, for the period 1914-15 through 1956-57, are set forth in Table 23.

TABLE 23

TOTAL AND ADDITIONAL COMBINED SAFE SEASONAL SYSTEM YIELDS WITH PAMO "B" RESERVOIR FOR THE PERIOD 1914-15 THROUGH 1956-57

In Acre-Feet

	: Average	seasonal	draft	. ,	
	: Sutherland	4	0	•	Additional
Pamo "B"	: Reservoir,				combined safe
Reservoir	:with spillway				
storage	: gates, with				system yield
capacity	: capacity of	:capacity			creditable to
	: 37,430		:capacity ^b	: or the	Pamo "B"
	: acre-feet	:acre-feet	:	: system:	Reservoirb
90,000	3,600	8,700	400	12,700	3,900
90,000	5,000	0,100	400	129 100	3,900
135,000	5,400	8,400	1,300	15,100	6,300
257,000	<i>)</i> ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	٠, .٥٠	2,500		0,500
163,400	6,600	8,100	2,000	16,700	7,900
	-/	,			

- a. System consists of Sutherland Reservoir with spillway gates and Hodges and Pamo "B" Reservoirs operated coordinately assuming present land and water use in San Pasqual-Main Lake Hodges Basin.
- b. Assumes releases from Pamo"B" Reservoir to maintain ground water levels in San Pasqual-Main Lake Hodges Basin equal to those which would have prevailed with Sutherland and Hodges Reservoirs operated coordinately on a combined safe yield basis.

San Pasqual Dam, Reservoir, and Conveyance System. The San Pasqual Dam site is located on the San Dieguito River, southeast of the City of Escondido at the western end of San Pasqual Valley in Section 1, T. 13 S., R. 2 W., S. B. B. W. & M. Stream bed elevation at the dam site is 333 feet, United States Geological Survey datum. The drainage area above the dam site is 249 square miles, of which 54 square miles lie above existing Sutherland Dam. Mean seasonal runoff at San Pasqual Dam site is estimated to be 34,600 acre-feet during the 43-year period, 1914-15 through 1956-57, including spills from Sutherland Reservoir with that facility operated coordinately with existing Hodges Reservoir on a combined safe yield basis. Estimated net seasonal depth of evaporation at San Pasqual Reservoir site for this period is 3.24 feet.

Designs for the various sizes of dam considered at the San Pasqual site are based on topographic maps prepared by the State Department of Water Resources in 1957 at a scale of one inch equals 200 feet with a contour interval of 10 feet. Reservoir areas and capacities at various water surface elevations, estimated from United States Geological Survey maps at a scale of 1:24,000 with a 10-foot and 20-foot contour interval, are presented in Table 24.

TABLE 24

AREAS AND CAPACITIES OF SAN PASQUAL RESERVOIR

Water surface elevation, U.S.G.S. datum, in feet	Depth of wa at dam, in feet	: area,	ce :	Storage capacity, in acre-feet
333 340 350 360 370 380 400 413 420 440 445 460 470 480 500	7 17 27 37 47 67 80 87 107 112 127 137 147	127 292 738 1,143 1,351 2,271 2,920 3,283 4,164 4,360 4,757 5,050 5,228 5,638		423 2,520 7,670 17,070 29,500 65,800 100,000 121,300 195,800 220,000 285,000 335,000 384,800 493,500

An evaluation of San Pasqual Dam site was not presented in Bulletin No. 55. No geological information was available on the suitability of the foundation or abutments for construction of a dam at this site. Therefore a contract for the drilling of three exploratory holes and testing the underlying formation for water loss was entered into in January, 1958. The contract drilling work was supervised by Department geologists. One hole was drilled through the stream bed alluvium to a depth of 117 feet, of which 30 feet were in fractured or weathered granodiorite. A hole to a depth of 55 feet was drilled in the right abutment about 62 feet above stream bed, penetrating 20 feet of a fractured and weathered transition zone between granodiorite and tonalite. The third hole was drilled at the right abutment at a probable spillway or auxiliary dam location. The hole was drilled to a depth of 100 feet, of which 88 feet were in decomposed granitic rock and 12 feet were in badly weathered tonalite. Location of these exploratory holes is shown on Plates 4 and 19.

To estimate the required depth of stripping and excavation in the stream bed, five undisturbed samples were secured during drilling of the exploratory hole in the alluvium and were tested to determine grain size distribution, plasticity, specific gravity, permeability, field density, and shear strength. Results of these tests are contained in Appendix J.

Based on geologic mapping of the dam site and results of the drilling program, the site is considered suitable for construction of earthfill dams up to a height of about 170 feet above stream bed, which is about the upper limit of height from a topographic standpoint.

To obtain the greatest practicable degree of conservation, a dam with a height of 157 feet above stream bed and creating a reservoir storage capacity of 335,000 acre-feet was selected for study. In addition, economic considerations indicated that alternative sizes should also be considered. Accordingly, two smaller dams with reservoir capacities of 100,000 and 220,000 acre-feet and heights of 100 and 132 feet, respectively, were also considered. Reservoir yield studies and cost estimates were prepared for these three sizes of dam at the San Pasqual Dam site.

A reconnaissance survey of the dam and reservoir area revealed suitable materials for the impervious core and random sections of the largest dam contemplated could be obtained within a distance of about one mile upstream and downstream from the site. A quarry site for rock riprap is located just upstream from the left abutment.

Three samples of impervious material and one sample of pervious material were collected from prospective borrow areas and were tested to determine grain size distribution, plasticity, specific gravity, maximum density at optimum moisture, and permeability. One impervious sample was also tested to determine shear strength of the material. Results of laboratory soil analyses are presented in Appendix J.

Tests of the pervious samples secured from the stream channel deposits indicate that the particle sizes were too uniform and the deposits
do not contain sufficient coarse material to provide stable fill slopes. Cost
estimates are, therefore, based on random upstream and downstream sections
containing a mixture of channel sediments and the coarser impervious materials secured by ripping the harder underlying formation in borrow areas adjacent to the stream and from spillway excavation. Soil tests further
revealed that upstream and downstream slopes of 3:1 for all three dams at
San Pasqual Site would be suitable.

The impervious section for all three dams would have an upstream and downstream slope of 1:1. The upstream face and downstream toe of all three dams would be protected against wave action and erosion from spillway discharges by rock riprap placed to a depth of three feet normal to the slope. Crest widths would be 30 feet, comprising a 10-foot width for the impervious core and a 10-foot width each for the upstream and downstream random sections.

Auxiliary dams would not be required for the 100-foot high dam, but the larger dams would require two auxiliary dams, with upstream and downstream slopes of $2\frac{1}{2}$:1, located along the right abutment.

On the basis of field geological inspection of the dam site and the results of subsurface exploration, it was estimated that stripping in the stream channel would be necessary to a depth of about 90 feet under the impervious section and 35 feet under the random section. Stripping from the right abutment would be 10 feet and 35 feet under the pervious and impervious sections, respectively, and, from the left abutment, 5 feet and 15 feet under the pervious and impervious sections, respectively. Stripping under the auxiliary dams located along the right abutment would be approximately 10 feet.

It was evident, from tests of water loss in the formation made during the exploratory drilling and from visual inspection of the dam site, that

moderate grouting would be required to prevent leakage in the foundation and abutments. Results of water tests are contained in Table J-3 of Appendix J.

The estimated peak flow of a once-in-100-year flood and a once-in-1,000-year flood at San Pasqual Dam site is 80,000 second-feet and 147,000 second-feet, respectively. Reduction of a once-in-100-year flood followed three days later with a once-in-1,000-year flood for the various sizes of dams and reservoir considered at the site is indicated in the following tabulation:

Height of dam crest above stream bed, in feet	Gross reservoir storage capacity, in acre-feet	Peak inflow of a once-in- 100-year flood, in second-feet	Peak in- flow of a once-in- 1,000-year flood, in second-feet	Peak spillway discharge, in second-feet	Maximum head on spillway, in feet
100	1.00,000	80,000	147,000	123,300	15
132	220,000	80,000	147,000	115,600	14
157	335,000	80,000	147,000	111,800	14

A five-foot residual freeboard between the maximum water surface at flood stage and the dam crest was assumed in the design of the two smaller size dams and a six-foot residual freeboard was assumed in the design of the larger size dam. Spillways would have a net crest length of 600 feet and would consist of a concrete-lined overpour chute with ogee weir control section. The spillway weir for the 100-foot and 132-foot high dams would be located in saddles just west of the right abutment. The spillway chutes would convey water to a well defined canyon confluent to the San Dieguito River. The spillway weir for the larger dam is located at the right abutment immediately adjacent to the fill of the dam. Overpour would discharge through the spillway chute directly into the San Dieguito River. Location of main and auxiliary dams and spillway for the largest size reservoir considered are shown on Plate 19.

The outlet works intake structure, located at the upstream toe of each dam near the left abutment, would be a vertical reinforced concrete tower. But—terfly valves would be located at vertical intervals within the tower to permit withdrawals from various elevations within the reservoir. Five such valves would be provided for the 157-foot high dam, with four valves for the 132-foot high dam and three valves for the 100-foot high dam. Trash racks would be provided at all intakes. A high pressure slide sluice gate with trash rack would be provided at the foot of the tower. A channel would be excavated between the stream channel and the intake tower to permit diversion of low flows through the dams.

A steel pipe line, encased in concrete, would extend beneath the dam from the intake structure to the control valve house at the downstream toe. The conduit would include cutoff collars within the impervious section of the dam. A bifurcation structure would be located in the control valve house, permitting the discharge of water either through a gate valve for sluicing directly into the San Dieguito River or through a gate valve into a conduit leading to Miramar Reservoir and to Lake Hodges.

Dams 100 feet and 132 feet high could be constructed in one and two years, respectively, while the larger dam would require two and one-half years for construction. It was assumed that diversion of summer flows in San Dieguito River during construction would be effected through the outlet works and that winter flows would pass through an uncompleted portion of the fill in the channel section.

The City of San Diego owns the lands on which San Pasqual Dam site is located and also a considerable portion of the reservoir area. The value of City lands and the cost of acquisition of privately—owned lands required for the project were estimated by appraisers of the State Department of Water

Resources. The total acreage, and the number of privately-owned parcels that would be acquired for the three sizes of reservoir are presented in the following tabulation:

Gross reservoir		dam and res	Estimated number of privately-	
storage capacity, in acre-feet	City-owned land	Privately- owned land	Total	owned parcels to be acquired
100,000	3,060	1,310	4,370	50
220,000	3,810	2,090	5,900	70
335,000	3,980	2,590	6,570	75

Construction of San Pasqual Reservoir would inundate a portion of State Highway No. 78 between Ramona and the City of Escondido. The estimate of the cost of a development at the San Pasqual site includes the cost of relocating the highway from its existing alignment along the north side of San Pasqual Valley to a route south of San Pasqual Valley through Green Valley. The new alignment would be approximately three miles greater in length than the present route. The estimate also includes the cost of relocating power and telephone lines within the project area.

To permit development of the ground water supply in the underlying basin, wells would be drilled and equipped with submersible pumps and motors. Concrete towers could be extended above ground level to facilitate removal of pumping equipment for use elsewhere when water is impounded in the reservoir. A pipe line distribution system from the wells to the intake of the outlet works of the dam would be provided. Costs of wells, pumps, motors, pipe line, and appurtenances are included in a seperate cost estimate and is presented in Appendix K.

San Pasqual ground water basin would be operated coordinately with

the three sizes of surface reservoir whenever reservoir stages permitted. Since it is not feasible to withdraw the entire system yield from ground water storage at the end of a drought period, it would be advisable to obtain a portion of the yield from ground water whenever surface reservoir levels dropped below an elevation of about 420 feet. Development of ground water reservoirs does not result in evaporation losses, associated with the operation of surface storage reservoirs, and such development within alluvial—filled surface reservoir areas has become accepted practice in San Diego County during the recent drought.

Under planned coordinate operation of San Pasqual Basin and San Pasqual Reservoir for the period 1914-15 through 1956-57, ground water levels throughout the main basin and canyons would be lowered an average of approximately 80 feet below ground surface at the end of a drought period. This maximum average lowering would range from about 10 feet near San Pasqual Dam to approximately 150 feet at the eastern end of San Pasqual Basin. Average lowering of ground water levels during the period 1914-15 through 1956-57 would be approximately 5 feet, with the average varying from about 1 foot near San Pasqual Dam to about 10 feet in the eastern portion of San Pasqual Basin.

General features and capital and annual costs of three sizes of dam and reservoir at the San Pasqual site, including development of the ground water within the reservoir area, are presented in Table 25, while Table 26 contains costs and a description of wells, pumping equipment, and pipe lines for development of ground water reserves in the reservoir area. Detailed estimates of costs are contained in Appendix K. The plan, profile, and section of the 157-foot high dam are shown on Plate 19.

GENERAL FEATURES OF THREE SIZES OF DAM AND RESERVOIR AT THE SAN PASQUAL SITE ON SAN DIEGUITO RIVER

Cheracteristics of Site
Drainage area-249 square miles
Drainage area below Sutherland Dam--195 aquare miles
Estimated average seasonal runoff below Sutherland Dam--23,100 acre-feet
Estimated average net seasonal depth of evaporation--3.24 feet
Estimated sedimentation--2,400 acre-feet average for 40-year amortization period
Elevation of stream bed, U.S.G.S. datum--333 feet

	Cross rose	rvoir storage	conscity
		in acre-feeta	capacity,
		: 257,000 :	372,000
	: 137,000	: 251,000	312,000
Earthfill Dam	lan	1. 65	lino
Crest elevation, in feet, U.S.G.S.	433	465	490
Crest length, in feet	1,440	2,745 ^b	4,190
Crest width, in feet	30	30	30
Meight, spillway lip above stream bed, in feet	80	113	137
Side slopes, upstream and downstream	3:1	3:1	3:1
Freeboard, above spillway lip, in feet	20	19 4,341,000 ^b	20,
Volume of fill, in cubic yards	2,670,000	4,341,000 ^b	6,481,000 ^b
•	, , ,		
Reservoir			
Surface area at spillway lip, in acres	2,920	4,360	5,050
Net storage capacity at spillway lip,	-,,	.,500	,,,,,
in acre-feet	97 600	217,600	332,600
		ir with concre	
Type of spillway			111,800
Spillway discharge capacity, in second-feet	123,330	66-inch	Two 60-inch
Type of outlet	48-inch		
	diameter	diameter	diameter
	steel pipe	steel pipe	steel pipes
Additional safe seasonal yield to the			
City of San Diego from the system, due			
to San Pasqual Reservoir, in acre-feetc	8,300	13,800	18,600
Incremental safe seasonal yield from the			
system due to San Pasqual Reservoir,			
in acre-feet ^c		5,500	4,800
			,

GENERAL FEATURES OF THREE SIZES OF DAM AND RESERVOIR AT THE SAN PASQUAL SITE ON SAN DIEGUITO RIVER (continued)

	: Gross reservoir storage capacity, in acre-feet a				
	•	137,000	<u>:</u>	257,000	: 372,000
Capital Costs Dam and reservoir, including ground					
water development Per acre-foot of storage	\$11	1,194,300 104	\$17	7,163,700	\$20,807,900 56
Per acre-foot of additional net safe seasonal yield from the system		1,710		1,244	1,119
Annual Costs Dam and reservoir, including ground					
water development Per acre-foot of additional net safe	\$	613,000	\$	827,200	\$ 1,004,700
seasonal yield from the system Per acre-foot of incremental net safe		82		60	54
yield from the system				39	37

a. Includes 37,000 acre-feet of ground water storage underlying the reservoir area. General features for developing ground water storage underlying the reservoir area are presented in Table 26.

b. Includes auxiliary dams.

c. System consists of San Pasqual Reservoir and development of ground water underlying the reservoir area operated coordinately with Sutherland Reservoir with spillway gates and Hodges Reservoir.

TABLE 26

GENERAL FEATURES OF WELLS, PUMPING PLANTS, AND CONVEYANCE FACILITIES FOR GROUND WATER DEVELOPMENT WITHIN SAN PASQUAL RESERVOIR AREA

Project Facilities	,
Number of 16-inch diameter gravel-packed wells to be constructed	13
Average depth of new wells, in feet	180
Average yield per new well, in gallons per minute	750
Motor horse power to operate submersible pumps	30 and 50
Length of pipe lines, in feet	
10-inch	6,300
12-inch	7,000
16-inch	3,300
18-inch	1,900
20-inch	2,500
22-inch	7,100
30-inch	12,000
Capital Costs	
Wells, pumping equipment, pipe lines	\$795,600 [*]
Per acre-foot of 37,000 acre-feet of usable ground water storage with maximum average ground water level lowering of 80 feet	22*

^{*} Land and improvement costs not included.

The yield from San Pasqual Reservoir would be conveyed through a reinforced-concrete steel cylinder pipe line, with an initial elevation of 340 feet, to a point one mile downstream from the dam, where a portion of the yield would be discharged through a gate valve into a three and one-half mile long canal. This canal would extend along the south side of San Dieguito River to Lake Hodges, terminating at a point northwest of Battle Mountain at an elevation of 317 feet. The remaining portion of the yield would be pumped through a 12-mile long reinforced-concrete steel cylinder pipe line to proposed Miramar Dam, which will have a spillway lip elevation of 710 feet. A gravel access road would be constructed along the north side of the canal. Pipe line and canal alignment were chosen after an examination of the topography of the area, as shown on United States Geological Survey maps at a scale of 1:24,000 and a contour interval of 20 feet, and is shown on Plate 17.

The pumping plant would be located at the southeastern edge of Lake Hodges Basin at an elevation of 340 feet. The pumping plant for the largest size reservoir considered, including maximum utilization of the ground water within the reservoir area, would have an installed capacity of 2,000 horsepower. From the pumping plant, the pipe line would continue south about 3,000 feet to a point between Indian and Bernardo Canyons, at an elevation of 720 feet. From this location, the conduit alignment between San Pasqual and Miramar Reservoirs becomes the same as the gravity conduit from Pamo Reservoir, previously described. High pressure pipe would be used for the crossings of Bernardo Canyon, Green Valley, and Los Penasquitos Canyon, and at other locations necessary.

Pipe line sizes and capacities would vary in accordance with the maximum monthly draft for the three sizes of San Pasqual Reservoir considered.

Releases would be made to Lake Hodges in accordance with the demand schedule of the service area of the reservoir. Sizes and capacities of the conduit for the various sizes of reservoir are set forth in the following tabulation:

		Con	nveyance facil	lities	
Surface and		Pipe	line		Capacity of canal from
ground water		San Pasqual Dam Pumping plant to to pumping plant Miramar Reservoir			
storage capacity, in acre-feet	Inside Capacity Inside diameter, in second diameter		Capacity in second- feet	Lake Hodges, in second-feet	
137,000	36	30	22	8	22
257,000	40	40	30	18	22
372,000	717	52	36	29	22

Capital and annual costs of the conveyance facilities for reservoirs considered at the San Pasqual site on the San Dieguito River are presented in Appendix K. The cost of electrical energy for the pumping plant was based on average levels in San Pasqual Reservoir during the period 1914-15 through 1956-57.

Estimates of yield from reservoirs considered at the San Pasqual site were based on the previously discussed combined safe yield operation. The safe yield of the reservoir system would first be applied as a draft on Hodges Reservoir alone until its storage was depleted, then the combined yield would be applied as a draft on Sutherland and San Pasqual Reservoirs in accordance with the balanced storage concept. Diversions from Hodges Reservoir would continue to take place whenever necessary to maintain the dead storage level.

Total and additional combined safe seasonal system yields and average seasonal drafts on existing Sutherland, Hodges, and San Pasqual Reservoirs, for each of the three sizes of reservoir considered at the San Pasqual site,

including yield from San Pasqual Basin, for the period 1914-15 through 1956-57, are presented in Table 27.

TABLE 27

TOTAL AND ADDITIONAL
COMBINED SAFE SEASONAL SYSTEM YIELDS
WITH SAN PASQUAL RESERVOIR
FOR THE PERIOD 1914-15 THROUGH 1956-57

In Acre-Feet

	: Average	seasonal di	raft	•	
	: Sutherland	•			: Additional
San	: Reservoir,	: Hodges	: Pasqual	:combined:	combined safe
Pasqual.	:with spillway	y:Reservoir:	Reservoir	: safe :	: seasonal
Reservoir	: gates, with	: with	: with	:seasonal:	system yield
storage	: capacity of	: capacity:	:indicated		creditable to
capacityb	: 37,430	:of 33,500	capacity	: of the	: San Pasqual
	: acre-feet	:acre-feet:		: system :	Reservoir
3.55 0.00	6 000	7 1.00	0 1.00	35.200	0.000
137,000	6,300	7,400	3,400	17,100	8,300
057.000	0.200	5,600	7 700	22,600	13,800
257,000	9,300	5,000	7,700	22,000	13,000
372,000	11,500	3,100	12,800	27,400	18,600
312,000	المار وسد	5,100	12,000	219400	10,000

- a. System consists of Sutherland Reservoir with spillway gates and Hodges and San Pasqual Reservoirs operated coordinately, including development of ground water underlying San Pasqual Reservoir area.
- b. Includes 37,000 acre-feet of ground water storage capacity underlying San Pasqual Reservoir area.

Super Hodges Dam, Reservoir, and Conveyance System. Super Hodges Dam site is approximately 150 feet downstream from existing Hodges Dam. Stream bed elevation at the dam site is 200 feet, United States Geological Survey datum. The drainage area above the site comprises 302 square miles, of which 54 square miles lie above existing Sutherland Dam. Mean seasonal runoff into existing Hodges Reservoir is estimated to be 38,700 acre-feet during the period from 1914-15 through 1956-57, including spills from Sutherland Reservoir, with that

facility operated coordinately with existing Hodges Reservoir on a combined safe yield basis and assuming present conditions of land and water use in San Pasqual-Main Lake Hodges Basin. Estimated net seasonal depth of evaporation for this period is 2.79 feet.

A topographic map prepared by the City of San Diego in 1942 and revised in 1946 was used for dam site studies. Reservoir area and capacity relationships were taken from data presented in Bulletin No. 55 and from a topographic map prepared by photogrammetric methods to a scale of one inch equals 400 feet. The contour interval of this map is 10 feet. Deposition of silt in existing Hodges Reservoir was considered in estimating reservoir areas and capacities. The reservoir data is given in Table 28.

TABLE 28

AREAS AND CAPACITIES OF SUPER HODGES RESERVOIR

Water surface	8 D D C		Character and the
elevation			Storage capacity,
U.S.G.S. datum,		area, :	in
in feet	in feet	: in acres :	acre-feet
220	1	1	1
230	11	8	40
240	21	27	207
250	31	87	745
260	41	177	2,035
270	51	254	4,180
280	61	382	7,340
290	71	545	11,950
300	81	778	18,530
310	91	1,075	27,780
320	101	1,405	40,140
330	111	1,951	56,920
340	121	2,396	78,660
350	131	2,799	104,630
360	141	3,710	137,180
365	146	4,056	157,300
370	151	4,401	177,730
380	161	5,046	224,960
390	171	5,767	279,030
395	176	6,189	310,000
400	181	6,610	340,920
403	184	6,859	365,000
405	104	09057	500,000

The geology of the dam site was described in considerable detail in Bulletin No. 55. The more important of these comments are given below:

*The area in the vicinity of the dam site contains a series of old volcanics and sediments that have been intruded by granitic material and have been metamorphosed to varying degrees. No major faults were noted in the area, but shearing and minor faulting are found at many localities. This general area is considered to be seismically active.

"Rocks at the proposed dam site appear to be meta-volcanics, with the more basic rocks in the left abutment and channel sections giving way to a more acid type on the upper right abutment. Considerable of the rock in the present spillway area is a meta-rhyolite and more of this rock is found at higher elevations, both upstream and downstream from the site. Practically all of the rock, when freshly exposed, is hard and durable and capable of carrying the load of the dams being considered.

"All the foundation rock at the site is strongly jointed. Some local crushing and shearing is noted and gougy seams are found in the more weathered upper portions. The most notable set of joints is on the right abutment where a dip of 25 to 40 degrees toward the channel is joined. These joints cut the rock into slabs, five to ten feet in thickness, and produce sliding planes that may require some special consideration. A nearly vertical joint system parallel to the channel is also quite pronounced. There is a set of streamward dipping joints on the left abutment, quite similar in nature to the set on the right abutment. It was observed in the road cuts below the zone of weathering (approximately 30 feet normal to the surface) that the joints were tighter and cleaner and it appears that they could be properly treated by washing and grouting.

"A strong shear zone exists on the right abutment at elevation 325. It strikes approximately N. 72° E. and dips into the abutment approximately 40 degrees. It extends upstream under the existing spillway apron and downstream beyond the limits of the location considered for a future dam. Material in the zone appears to be soft light colored tuffaceous material and may have developed from crushing of the meta-rhyolite. This material may improve with depth, but it should be considered a zone of weakness and accorded special treatment. This shear zone is about 25 feet in thickness and has been eroded to depths of over 20 feet by water flowing over the existing spillway."

In 1949, the United States Army Corps of Engineers made seven core borings at the dam site. One hole was located on the left abutment, two in the stream channel, and four on the right abutment. These holes ranged in depth from 33.7 feet to 141.8 feet, with a total footage of 432.8 feet. Of this total footage, 18.6 feet were in overburden and 414.2 feet were core drilled in rock. Location and logs of the holes are shown in the Corps of Engineers' report entitled "Appendixes to Accompany Report on Survey, Flood Control, San Dieguito River, San Diego County, California", dated March 1, 1956. Location of the holes are also shown on Plate 20.

Previous geologic studies, augmented by more recent surveys, indicate that the Super Hodges Dam site is suitable for construction of concrete gravity, rockfill, or earth fill dams up to a height of about 220 feet above stream bed. In order to reduce waste to the ocean to the greatest practicable extent, a dam with a height of 220 feet above stream bed was found to be the optimum structure. Economic considerations indicated that dams with heights of 184 feet and 213 feet should also be considered.

Reconnaissance of the area in the vicinity of Super Hodges Reservoir and Dam site indicated that rock materials were available in sufficient quantities for construction of a rockfill dam with a height of 220 feet. Preliminary designs and cost estimates were prepared for rockfill and concrete gravity dams of this height. The previous investigation, reported in Bulletin No. 55, considered only a concrete gravity structure at this site.

On the basis of very preliminary cost comparisons, it appeared that the cost of a rockfill dam, with a side channel spillway at the right abutment immediately adjacent to the dam fill, would be in the same order of magnitude as the cost of a concrete gravity dam. However, no information was available regarding the quality of the available rock, and the costs of quarrying, hauling, and placing rock and maintaining the upstream impervious face of the dam were somewhat speculative in nature. Consequently, cost estimates were based on preliminary designs of three sizes of concrete gravity dam at the Super Hodges site.

Designs, with the possible exception of outlet works, closely

approximate plans shown in Bulletin No. 55 and in the United States Army

Corps of Engineers' "Report on Survey, Flood Control, San Dieguito River,

San Diego County, California", dated March 1, 1956. Estimates of costs are based on a vertical upstream face and a downstream slope of 0.8 horizontal to 1.0 vertical. Width of dam crest would be 15 feet. This would provide for a single-lane roadway, carried over the spillway by a reinforced concrete bridge. It was also assumed that concrete aggregate would be obtained from Poway Valley, approximately nine miles southeast of the Super Hodges Dam site. Although this aggregate is considered somewhat reactive, the adverse effects will be greatly reduced when combined with low alkali cement and other appropriate admixtures. This source of aggregate has been utilized successfully in construction of Sutherland Dam.

On the basis of geological reconnaissance, it was estimated that stripping in the stream channel to depths of 15 feet would be required. Stripping from the right abutment in the shear zone would be about 85 feet, while stripping elsewhere from the right abutment would be approximately 20 feet. Stripping from the steep left abutment would be in the order of 15 feet. It was recommended, by the United States Army Corps of Engineers, that foundation rock in both abutments and between abutments be grouted, with the amount of cement required probably not exceeding one-half sack per linear foot of grout hole.

The estimated peak flow of a once-in-100-year flood and a once-in-1,000-year flood at Super Hodges Dam-site is 88,400 second-feet and 163,200 second-feet, respectively. Reduction of a once-in-100-year flood followed three days later by a once-in-1,000-year flood for various sizes of dam and reservoir is shown in the following tabulation:

Height of dam crest above stream bed, in feet	Gross reservoir storage capacity, in acre-feet	Peak inflow of a once- in- 100-year flood, in second-feet	Peak inflow of a once- im- 1,000-year flood, in second-feet	Peak spillway discharge, in second-feet	Maximum head on spillway, in feet
184	157,300	88 ,400	163,200	115,000	18
213	310,000	88,400	163,200	102,000	17
220	365,000	88,400	163,200	92,800	16

A one-foot residual freeboard between the maximum water surface at flood stage and the dam crest was assumed in the design of all three dams. An ogee overflow spillway, with a net length of 400 feet, would be located over the middle section of the dam. A deflecting lip or bucket would be provided near the downstream toe. The spillway would be divided by training walls into two central sections with widths of 100 feet and 200 feet, respectively, and end sections with widths of 50 feet each. Spillway gates were not included in the estimate.

Outlet works would be located near the right abutment of the dam. Intake conduits for the outlet works would be located at five levels, 28 feet apart for the two larger dams and at four levels, 25 feet apart, for the 184-foot high dam. These conduits would extend from the upstream face into the dam to a vertical well. Trash racks are provided on the face of the dam at each intake, and gate valves control the flow in the intake conduits.

The main outlet conduit consists of a welded steel pipe extending from the bottom of the vertical well to a control valve house located about 400 feet downstream from the dam where a bifurcation structure would direct the water to either the existing conduit to San Dieguito Reservoir or to a pipe line to the proposed Miramar Reservoir. A needle valve would be provided in the valve house to control flows to San Dieguito Reservoir, while a gate valve would control flows to Miramar Reservoir. Intake conduits, vertical well,

and main outlet pipe line are 30 inches, 42 inches, and 48 inches in diameter for the 184-foot, 213-foot, and 220-foot high dams, respectively.

Cost estimates include provision for a four by five-foot rectangular concrete sluicing outlet near the base in the center of the two larger dams. A three by four-foot conduit is provided in the smaller structures. A trash rack would be provided at the intake of the sluicing outlet and flow therein would be controlled by two emergency slide gates in tandem.

The 184-foot high concrete gravity dam could be constructed in about two years, while the two larger dams would probably require three years to complete. Normal flows in the San Dieguito River would be impounded in existing Lake Hodges during construction. A low point would be maintained near the center of the prospective dam during concrete placement to accommodate spills from existing Lake Hodges.

The City of San Diego owns the land on which Super Hodges Dam site is located and most of that portion of the reservoir area below an elevation of 395 feet. The value of City and privately-owned lands and improvements required for the project were estimated by appraisers of the State Department of Water Resources. Acreage and the number of privately-owned parcels that would be acquired for the three sizes of reservoir are presented in the following tabulation:

	Area within	dam and reser	voir sites,	Estimated number of
Gross reservoir storage capacity, in acre-feet	City-owned land	Privately- owned land	Total	privately- owned parcels to be acquired
157,300	6,680	200	6,880	157
310,000	7,740	1,520	9,260	220
365,000	8,100	1,990	10,090	250

The cost of relocation of State Highway No. 78 and U. S. Highway
No. 395 would constitute a considerable portion of the cost of a development at
the Super Hodges site. U. S. Highway No. 395 presently crosses existing Lake
Hodges south of the City of Escondido on a two-lane bridge. Since the Division
of Highways, State Department of Public Works, is currently planning to convert
this highway to a four-lane facility, their estimate of the cost of relocation
was based on a four-lane bridge and approaches. Cost of construction of a new
bridge across Green Valley Creek is also included in the estimate. State
Highway No. 78 would require minor relocation along the north periphery of
San Pasqual Valley and either major realignment or a bridge, would be necessary
at Bach Canyon. Estimates of cost of a facility at the Super Hodges site also
include cost of relocating affected power, telephone and gas lines.

Development of the ground water supply within San Pasqual-Main Lake Hodges Basin could be accomplished in a manner similar to that described for San Pasqual Basin with a dam at the San Pasqual site. Although Super Hodges Reservoir would not inundate the eastern portion of San Pasqual Basin, it is assumed that it would be necessary and desirable for the entity withdrawing ground water from within the reservoir area to acquire either the land or the rights to use underlying ground water within the entire San Pasqual Basin.

Conjunctive operation of San Pasqual-Main Lake Hodges Basin with Super Hodges Reservoir would provide slightly more yield from ground water than that obtained from the development of ground water within the San Pasqual Reservoir area. However, even with the yield from the ground water basin, it was apparent that the Super Hodges project is not competitive with other alternative developments considered. For this reason, costs of developing ground water supplies with a reservoir at the Super Hodges site were not estimated.

Presented in Table 29 are pertinent data with respect to general features and capital and annual costs of the three sizes of dam and reservoir at the Super Hodges site on the San Dieguito River. Detailed estimates of costs including cost of highway relocation as estimated by the Division of Highways, State Department of Public Works, are included in Appendix K. The plan, profile, and section of the dam creating a reservoir with a storage capacity of 365,000 acre-feet are shown on Plate 20.

TABLE 29

GENERAL FEATURES OF THREE SIZES OF DAM AND RESERVOIR AT THE SUPER HODGES SITE ON SAN DIEGUITO RIVER

Characteristics of Site

Drainage area 302 square miles

Drainage area below Sutherland Dam-248 square miles

Estimated average seasonal runoff below Sutherland Dam-27,200 acre-feet

Estimated average net seasonal depth of evaporation-2.79 feet

Estimated sedimentation-3,000 acre-feet, average for 40-year amortization period

Elevation of stream bed, U.S.G.S. datum-200 feet

		n acre-feet	
	: 157,300	: 310,000	365 , 000
Concrete Gravity Dam			
Crest elevation, in feet, U.S.G.S.	384	413	
Crest length, in feet	880	975	1,045
Crest width, in feet	15	15	15
Height, spillway lip above stream bed,			
in feet	_	195	
Side slopes, upstream and downstream	Ver	tical and 0	
Freeboard, above spillway lip, in feet	19	18	17
Volume of mass concrete, in cubic yards	293,000	407,000	455,000
Reservoir			
Surface area at spillway lip, in acres	4,,056	6,189	6,859
Net storage capacity at spillway lip,			
in acre-feet	154,300		
Type of spillway	Standard	ogee weir,	overflow type
Spillway discharge capacity, in second-feet	115,000		92,800
Type of outlet	30-inch	42-inch	48-inch
	diameter	diameter	diameter
	steel pipe	steel pipe	steel pipe
Additional safe seasonal yield to the City of San Diego from the system due to			
Super Hodges Reservoir, in acre-feeta	4,200	11,200	13,700
Incremental safe seasonal yield from the system due to Super Hodges Reservoir,			
in acre-feeta	c a	7,000	2,500

GENERAL FEATURES OF THREE SIZES OF DAM AND RESERVOIR AT THE SUPER HODGES SITE ON SAN DIEGUITO RIVER (continued)

	:Gross reser	rvoir storag	
	: 157,300	: 310,000	: 365,000
Capital Costs Dam and reservoir Per acre-foot of storage Per acre-foot of additional net safe seasonal yield	\$19,120,700 \$ 122 4,553	32,435,400 105 2,896	\$35,339,900 97 2,580
Annual Costs Dam and reservoir Per acre-foot of additional net safe seasonal yield from the system	\$911,300 217	\$1,5 Ы4 , 000	\$1, 683,400
Per acre-foot of incremental net safe seasonal yield from the system	-	90	56

Reservoir operated coordinately, assuming present land and water use in San Pasqual-Main Lake Hodges Basin for the area not inundated by Super Hodges Reservoir.

It was assumed that the conveyance facility from existing Hodges Reservoir to San Dieguito Reservoir would be utilized if Super Hodges Dam were constructed. The increase in yield resulting from a development at the Super Hodges site, however, would necessitate construction of two pumping plants and a 10-mile reinforced concrete steel cylinder pipe line from Super Hodges Reservoir, at initial elevation of 220 feet, to the proposed Miramar Reservoir, having a water surface elevation at the spillway lip of 710 feet. United States Geological Survey topographic maps were used in selecting the conduit alignment, shown on Plate 17.

The conduit from Super Hodges dam site would cross the San Dieguito River in a buried siphon approximately 500 feet downstream from the toe of the dam and would extend downstream along the south edge of the San Dieguito River a distance of approximately 3,000 feet, from which point it would extend southerly about 1,300 feet to Pumping Plant No. 1 at an elevation of 220 feet. From Pumping Plant No. 1, the pipe line would continue in a general southerly direction approximately three miles to Pumping Plant No. 2, located on the south side of La Jolla Valley at an elevation of about 535 feet.

The conduit would then extend southerly from the pumping plant, crossing Los Penasquitos Creek approximately one mile west of U. S. Highway No. 395, to a point about 3,000 feet south of Los Penasquitos Creek. From this point, the conduit would extend in a southeasterly direction about two miles to Miramar Reservoir. High pressure pipe would be used where needed on the discharge side of the pumping plants and across La Jolla Valley and Los Penasquitos Canyon.

Pipe lines would vary in size and capacity in accordance with the maximum monthly flow, which, in turn, would depend upon the reservoir capacity.

Releases would be made to San Dieguito Reservoir in accordance with the demand schedule of the service area. These releases, however, would not exceed the 17 second-foot capacity of the existing conduit from Lake Hodges to San Dieguito Reservoir. Sizes and capacities of the Super Hodges-Miramar conduit for the three sizes of reservoir considered at the Super Hodges site are presented in the following tabulation:

Gross reservoir storage capacity, in acre-feet	Inside diameter of conduit, in inches	Design capacity of conduit, in second-feet
157,300	20	6.3
310,000	26	13.5
365,000	28	18.0

Capital and annual costs of the conveyance facilities considered for developments at the Super Hodges site are presented in Appendix K. The cost of electrical energy for the pumping plants was based on average levels in Super Hodges Reservoir during the period 1914-15 through 1956-57.

Estimates of yield from reservoirs considered at the Super Hodges site were based on a combined safe yield operation. However, when a development at the Super Hodges site is substituted for the existing Hodges Dam, the reservoir system within the watershed would be operated in a different manner than with prospective works at the Pamo "B" and San Pasqual sites. If the system yield was first applied as a draft on Super Hodges Reservoir alone until its storage was depleted, a portion of the supply stored in Sutherland Reservoir would spill. Operation of Super Hodges and Sutherland Reservoirs on the basis of balanced storage was selected as the most feasible plan of system operation.

Total and additional combined safe seasonal system yields and average seasonal drafts on Sutherland and Super Hodges reservoirs for each of the three sizes of reservoir considered at the Super Hodges site for the period 1914-15 through 1956-57 are presented in Table 30.

TABLE 30

TOTAL AND ADDITIONAL COMBINED SAFE SEASONAL SYSTEM YIELDS WITH SUPER HODGES RESERVOIR FOR THE PERIOD 1914-15 THROUGH 1956-572

In Acre-Feet

Super Hodges Reservoir storage capacity	2 Average sea 2:Sutherland Reser- 2: voir with spillway 3: gates with 4: capacity of 4: 37,430 acre-feet	s: Super Hodges Reservoir with indicated capacity	:safe seasonal : yield of the	: Additional :combined safe :seasonal yield :creditable to : Super Hodges : Reservoir
157,300	8,500	٤,500	13,000	4,200
310,000	10,900	9,100	20,000	11,200
365,000	11,400	11,100	22,500	13,700

a. System consists of Sutherland Reservoir with spillway gates and Super Hodges Reservoir operated coordinately, assuming present land and water use in that portion of San Pasqual-Main Lake Hodges Basin not inundated by Super Hodges Reservoir.

San Vicente Reservoir. As previously mentioned in this chapter, a considerable amount of water would spill from both Sutherland and Hodges Reservoirs and waste to the ocean under a combined safe yield operation. Storage is available in the City of San Diego's San Vicente Reservoir to regulate diversions from Sutherland Reservoir, during such periods of spill, in excess of the amount diverted under a combined safe yield operation.

The existing San Vicente Dam is a straight concrete gravity structure with central overpour spillway. It is 190 feet in height from stream bed to spillway crest, has a crest length of 980 feet, and creates a reservoir with a storage capacity of 90,200 acre-feet. Elevation of the spillway lip of the dam is 650 feet.

It is estimated that 5,300 acre-feet of storage is available in San Vicente Reservoir to regulate spills diverted from Sutherland Reservoir.

This estimate is based on the following assumptions regarding water supply:

- 1. The estimated mean seasonal natural runoff from the drainage area above San Vicente Reservoir is 7,800 acre-feet.
- 2. The estimated seasonal import of 75,450 acre-feet required in the City of San Diego's Alvarado Service Area in 1975 would be supplied from the First San Diego Aqueduct and regulated to a demand basis in San Vicente Reservoir.
- 3. The City's safe seasonal draft from San Vicente Reservoir would be 80,000 acre-feet in 1975, including imported water but excluding waters diverted from Sutherland Reservoir.

Spill salvaged from Sutherland Reservoir and conveyed to San Vicente Reservoir at times when downstream reservoirs were not spilling

would reduce yields from downstream developments. For this reason, the only water considered available for diversion was the minimum monthly spill from any reservoir in the San Dieguito River watershed, either existing or potential, or the unused conveyance capacity of the Sutherland-San Vicente conduit, whichever was the least value. The amount of spills available for diversion decreases as storage is increased in the San Dieguito River watershed,

Table 31 lists the average annual spills diverted to San Vicente Reservoir and the total additional combined safe system yield of the San Dieguito River watershed and the drainage area above San Vicente Reservoir for both existing and potential plans of development, utilizing 5,300 acre-feet of storage in San Vicente Reservoir for regulation of spills from Sutherland Reservoir. Only the most promising plans for development in the San Dieguito River watershed were analyzed under coordinate operation with San Vicente Reservoir.

TOTAL AND ADDITIONAL COMBINED SAFE SEASONAL SYSTEM YIELDS UNDER COORDINATE OPERATION WITH SAN VICENTE RESERVOIR FROM EXISTING AND POTENTIAL PLANS OF DEVELOPMENT FOR THE PERIOD 1914-15 THROUGH 1956-57 OF THE SAN DIEGUITO RIVER

In Acre-Feet

	: Average	: Combined		•	Total combined	Addttonal com-	ŀ
Conditions of development	: annual	net safe	. 64 65	Net safe	safe seasonal	: bined net safe : seasonal avstem	
	: of spills : diverted	: yield from : the San	: Net safe	: seasonal	from the San	: yield creditable : to potential San	
dn 1	: from : Sutherland	: Dieguito : River sys-	: yield from : San Vicente	: diversion : of spills	s developments s and San Vicente	: Disguito River : developments	
San Dieguito River watershed	: Reservoir : to San : Vicente : Reservoir	: tem avail- : able to the : City of : San Diego	: Reservoir®	: to San : Vicente : Reservoir	Reservoir, available to the City of San Diego ^a	<pre>: under coordinated : operation with : San Vicente : Reservoir</pre>	
Existing Hodges and Sutherland Reservoir	5,500	8,200	5,200	006	14,300	â	
Hodges and Sutherland Reservoirs and San Pasqual-Main Lake Hodges Basin ^d	006°†	14,500	5,200	800	20,500	6,200	
Hodges, Sutherland, and Pamo Reservoir and San Pasqual-Main Lake Hodges Basind Pamo Reservoir capacity, in acre-feet 90,000 135,000	3,600 2,500 1,400	18,200 20,600 22,200	5,200 5,200 5,200	700 700 700	24, 100 26,500 28,100	9,800 12,200 13,800	
Hodges, Sutherland, and San Pasqual Reservoirs and development of ground water within San Pasqual Reservoir areae San Pasqual Reservoir capacity, in acre-feet 100,000 220,000 335,000	3,600 1,400 150	17,100 22,600 27,400	5,200 5,200 5,200	700 700 100 ^f	23,000 28,500 32,700	8,700 14,200 18,400	
Not deadlister of the Owner Aff 1970 and Onthe On							

Not including yield from 75,450 acre-feet of imported water. e e

Utilizing 5,300 acre-feet of storage capacity in San Vicente Reservoir.

Assuming present land and water use in San Pasqual-Main Lake Hodges Basin.

Includes spillway gates on Sutherland Reservoir and a maximum of 41,000 acre-feet of ground water storage depletion in San Pasqual-Main Lake Hodges Basin. • p

Includes spillway gates on Sutherland Reservoir and a maximum of 37,000 acre-feet of ground water storage depletion within San Pasqual Reservoir area. Utilizing only 900 acre-feet of storage capacity in San Vicente Reservoir.

Evaluation of additional combined safe seasonal yield from surface and ground water developments previously discussed in this chapter has been confined to those projects which are located within the San Dieguito River watershed. However, under the method of operation in which a portion of the spills are salvaged and diverted to San Vicente Reservoir, the total combined safe seasonal yield from existing facilities, considering only water from the San Dieguito River watershed, can be increased by about 900 acre-feet as shown in Table 31. Although the total combined safe seasonal yield from existing and potential developments increases as the total storage capacity is increased in the San Dieguito River watershed, the volume of spills available for transfer and the resulting yield decrease. This condition results in the additional combined safe seasonal yield from potential developments when considering transfer of spills being somewhat less than the additional yields derived without transfer of spills. In the comparison of plans of surface storage developments described in Chapter VI, it was assumed that an operation would be employed which involved the transfer, to San Vicente Reservoir, of a portion of the water which would have spilled from Sutherland Reservoir.

Under most of the plans of development considered, a portion of the spills which are available for transfer to San Vicente Reservoir would in turn spill from the latter reservoir unless either the purchase of imported water was reduced or the storage capacity of San Vicente Reservoir was increased. If the City reduced the purchase of imported water in order to conserve more local water, a monetary benefit would accrue to the City.

Table 32 presents the additional quantities of local water which could be conserved with maximum possible diversion of spills from Suther-land Reservoir and reduction in deliveries of imported water to San Vicente Reservoir for both existing and potential plans of development. The monetary benefits accruing to the City of San Diego as a result of reduction in purchases of imported water, computed at the current rate of \$17.00 per acre-foot, is also shown.

WATER BY DIVERSION OF SPILLS AND REDUCED DELIVERIES OF IMPORTED WATER FOR COMBINED SAFE SEASONAL SYSTEM YIELDS AND ADDITIONAL CONSERVATION OF LOCAL EXISTING AND POTENTIAL PLANS OF DEVELOPMENT FOR THE PERIOD 1914-15 THROUGH 1956-57

re-feet : Estimated	:Total average an- : average :nual usable sup- : annual :ply of local water; monetary	«.	vail- : City :	18,400 \$ 69,700	24,100 61,200	26,700 44,200 28,100 27,200		25,600 444,200	
Usable local water supply, in acre-feet	c.		purchasing imported water	18,	3,600 24,	2,600 1,600 28,			600 29s
. Usable loc	:Net combined safe: Average anseasonal system : nual addi- :yield, from San : tional con-	developments and :: San Vicente Res- :	<pre>:erwoir, available: :to the City of :San Diego^a :</pre>	rsb 14,300	20,500	24,100 26,500 28,100	ۇ ئ	23,000	28,500 32,700
	Conditions of development	San Dieguito River		Existing Hodges and Sutherland Reservoirsh Hodges and Sutherland Reservoir and	San Pasqual-Main Lake Hodges Basin ^c Hodges, Sutherland and Pamo Reservoirs and San Pasqual-Main Lake Hodges Basin ^c	Pamo Meservoir capacity, in acre-feet 90,000 135,000 163.100	Hodges, Sutherland and San Pasqual Reservoirs and development of ground water within San Pasqual Reservoir capacity,	100,000	220,000 335,000

Assuming present land and water use in San Pasqual-Main Lake Hodges Basin. ڡٛ

Includes spillway gates on Sutherland Reservoir and a maximum of 41,000 acre-feet of ground water storage depletion in San Pasqual-Main Lake Hodges Basin. ပိ

Includes spillway gates on Sutherland Reservoir and a maximum of 37,000 acre-feet of ground water storage depletion within San Pasqual Reservoir area. တွ်

of the San Dieguito River watershed and the watershed above San Vicente Reservoir would be increased without reducing imports to the latter reservoir. Enlarging this reservoir from a capacity of 90,200 acre-feet to a capacity of 174,000 acre-feet, at an estimated capital cost of \$6,719,000 at 1955 price levels, was described in Department of Water Resources Bulletin No. 3, "The California Water Plan", 1957, as a possible future development.

Water surface areas and reservoir storage capacities for various water surface elevations above the existing spillway lip were obtained from the City of San Diego. These data are shown in Table 33.

TABLE 33

AREAS AND CAPACITYES OF ENLARGED SAN VICENTE RESERVOIR

Water surfa elevation, U.S.G.S. De in feet	i Indetum, dept	crease in of water :	Water surface area, in acres	: : Storage capacity, : in acre-feet :
650 655 660 665 670 671 675 680 685 690 695 700 705 710 714		0 5 10 15 20 21 25 30 35 40 45 50 55 60 64 65	1,069 1,090 1,111 1,138 1,165 1,167 1,186 1,206 1,232 1,257 1,277 1,297 1,320 1,344 1,361 1,367	90,230 95,630 101,130 106,750 112,510 113,600 118,390 124,370 130,460 136,680 143,020 149,450 156,000 162,660 168,200 169,430

The following discussion pertaining to enlargement of San Vicente Reservoir was presented in Department of Water Resources Bulletin No. 61, "Feather River Project-Investigation of Alternative Aqueduct Routes to San Diego County", dated March, 1957,:

*Bedrock at the San Vicente Dam is composed of moderately jointed granitic and metamorphic rock which is hard and durable when fresh. No evidence of faulting was observed at the dam or in the nearby vicinity. The area is considered to be moderately active seismically as the Elsinore fault zone lies 24 miles to the northeast. The pointing of the foundation material is moderately strong with generally clean joints.

Many loose boulders are present and the depth of weathering varies with rock type. Stripping estimates for the right abutment would necessitate removal of about five feet of weathered rock and about five feet of jointed bedrock. The channel section downstream from the existing structure would require removal of about 12 feet of alluvial fill. Stripping on the left abutment would consist of the removal of about eight feet of weathered rock and about five feet of jointed metamorphic rock.

The existing dam was constructed with the consideration in mind of raising it at some future date, by adding concrete on the downstream side. Although grouting work done during the original construction work was based upon requirements for a higher dam, additional grouting may be required for the raising operations herein considered. No stepping or other special treatment was given to the downstream face of the existing dam to facilitate keying in the new concrete work. Studies indicate that special methods of construction will be required to properly place the new concrete on the old surface with due allowance and consideration for shrinkage due to cooling and settling. A further problem presented is that of securing a good seal along the upstream contact between the old structure and the new section. The surface between the new and old concrete must be thoroughly drained, and galleries provided to permit inspection of such drainage. In order to increase the storage capacity of the reservoir about 23,000 acrefeet, the crest of the spillway would be raised 21 feet above its present elevation to an elevation of 671 feet. Height of the enlarged dam would be 211 feet from stream bed to spillway crest.

For cost estimating purposes the plan of enlargement contemplates making the upstream face of the new work vertical, and providing a batter of 0.8:1 on the downstream face. The capacity and other features of the spillway would be similar to those now existing. The crest width of the raised dam would be 30 feet. The outlet tower would be raised by removing the existing operating platform and then extending the tower. The original design of the tower included allowance for this extension. A 36-inch diameter butterfly valve would be installed in the tower near the base of the new lift, and a 24-inch diameter

come valve would be placed in the outlet pipe which is presently plugged. No temporary outlet works would be necessary during the enlargement work, and it was assumed that there would be no appreciable interference with reservoir operation.

The City of San Diego now owns rights of way required for the enlargement, and no highway or utility relocation would be involved.

The required enlargement of San Vicente Reservoir to conserve varying quantities of spill from Sutherland Reservoir under existing and potential plans of development, the estimated capital and annual costs of such enlargement, and the total and additional combined safe system yield of the San Dieguito River systems and San Vicente Reservoir for various sizes of the latter reservoir are presented in Table 34. Detailed estimates of costs of enlargements are included in Appendix K. These were based on straight-line relationships between costs of enlargements discussed in Bulletin Nos. 3 and 61, adjusted to reflect prices prevailing in 1958.

TABLE 34

UNDER EXISTING AND POTENTIAL PLANS OF DEVELOPMENT IN SAN DIEGUITO RIVER WATERSHED ESTIMATED CAPITAL AND ANNUAL COSTS OF ENLARGING SAN VICENTE RESERVOIR ADDITIONAL AND TOTAL COMBINED SAFE SEASONAL SYSTEM YIELDS FOR THE PERIOD 1914-15 THROUGH 1956-57

	Estimated average coottal annual cost cost of of enlarged enlarged san Vicente Vicente Reservoir 1s,	\$7,963,200 \$376,000	7,602,800 359,000	6,545,700 308,900 4,743,600 223,600 3,038,000 142,900	6,545,700 3C8,°00 3,038,000 142,900
ot:	: Increase in : storage ca- : pacity of : San Vicente : Reservoir : required to : conserve and : regulate di- : verted spills, : in acre-feet	52,400	004,64	40,600 25,600 11,400	40,600 11,400
Safe seasonal yield of local water, in acre-feet	: Combined : safe seasonal : system yield : from San : Dieguito : River develop- : ments and en- : larged San : Vicente : Reservoir	18,400	24,100	26,700 28,100 28,700	25,600 29,100 32,700
l yield of local	: Additional : safe sea- : sonal yield : from diver- ted spills : secured by : enlarging : San Vicente : Reservoir	1,100	3,600	2,600 1,600 600	2,600
:Safe seasona	:Combined :safe seasonal :system yield :from San :Dieguito :River develop- :ments and :existing San :Vicente :Reservoir®	14,300	n 20,500	24,100 26,500 28,100	23,000 28,500 32,700
	Conditions of development in San Dieguito River watershed	Existing Hodges and Sutherland Reservoirs	Hodges and Sutherland Reservoirs and San Pasqual-Main Lake Hodges Basin ^c	Hodges, Sutherland, and Pamo Reservoirs and San Pasqual-Main Lake Hodges Basin ^o Pamo Reservoir capacity, in aore-feet 90,000 135,000	Hodges, Sutherland, and San Pasqual Reservoirs and development of ground water within San Pasqual Reservoir aread San Pasqual Reservoir Capacity, in acre-feet 100,000 220,000 335,000

Not including yield from 75,450 acre-feet of imported water. ಹ

Ď. °

Assuming present land and water use in San Pasqual-Main Lake Hodges Basin. Includes spillway gates on Sutherland Reservoir and a maximum of 41,000 acre-feet of ground water storage depletion in San Pasqual-Moin Lake Hodges Basin.

Includes spillway gates on Sutherland Reservoir and a maximum of 37,000 acre-feet of ground water storage depletion within San Pasmal Reservoir area. o.

The large floods of 1916, 1927, and 1937 caused extensive damage in the San Dieguito River watershed. Should a large flood occur under present conditions, the resultant damage would be several times greater than that caused by past floods of similar magnitude due to the large increase in the number and value of improvements in the overflow areas, particularly in San Dieguito Valley. In the upper and central parts of the San Dieguito River watershed, principally in San Pasqual Valley, floods cause damage to agricultural lands and scattered improvements along the principal streams. In San Dieguito Valley, the part of the watershed nearest the coast, industrial and residential property is susceptible to flood damage. An airport, the facilities of the Twenty-second Agricultural District used by the San Diego County Fair Association and the Del Mar Turf Club, and about 150 expensive beach homes are located in the coastal area.

Prior flood control investigations, and criteria used to estimate flood control benefits from operation of large water conservation reservoirs, are discussed first in this chapter, followed by a comparison of flood control accomplishments for the largest size of each of the reservoirs considered.

Prior Flood Control Investigations

The need for flood control measures on all streams flowing into the Pacific Ocean in San Diego County was recognized by the Congress in 1941, when it authorized studies for the determination of flood control requirements on these streams. As a result of this and subsequent legislation, the United States

Army Corps of Engineers prepared a "Report on Survey, Flood Control, San Dieguito River, San Diego County, California", dated March 1, 1956, submitted to Congress on November 20, 1957. It was recommended that the United States pay a share of the cost of a large locally-owned and sponsored multiple-purpose dam at the Hodges site. The dam would create a reservoir with a total storage capacity of 375,000 acre-feet, of which 85,000 acre-feet would be reserved for flood control, 280,000 acre-feet for water conservation, and 10,000 acre-feet for sedimentation. The reservoir would produce a substantial additional annual yield of water and would prevent most flood damage in the San Dieguito Valley. The average annual benefits from flood control were estimated at \$186,000.

On July 3, 1958, the 85th Congress, through enactment of Public Law 85-500, authorized the project described in the survey report at an estimated federal cost of \$1,961,000.

The State study, reported in Bulletin No. 55, recommended that a 310,000 acre-foot water conservation reservoir be constructed at the Hodges site to be operated in conjunction with the proposed Butherland Reservoir. With respect to flood control on the San Dieguito River, the report included the following recommendation:

"... that Federal assistance be sought in construction of an enlarged Hodges dam and conservation reservoir, on the basis and to the extent of resultant reduction in downstream flood damages."

Plans for water development in San Dieguito River watershed may include construction of large dams and reservoirs at other than the Super Hodges site. It is apparent that certain flood control benefits would accrue from use of these reservoirs even when operated exclusively for water conservation. Flood control benefits were estimated as part of this investigation for dams and reservoirs at the Pamo "B", San Pasqual, and Super Hodges site as an

aid in the final choice of a plan of development and to indicate the general order of magnitude of the benefits which would be realized.

Criteria for Determining Flood Control Accomplishments

Flood control accomplishments were evaluated only for the largest conservation reservoir considered at the Pamo "3", San Pasqual, and Super Hodges sites. No reservation of flood control storage is proposed in any of the structures considered, nor has the need for stream channel improvement been evaluated.

To facilitate the determination of the magnitude and occurrence of flood flows, hydrographs of flood flows on the main stream and its principal tributary, Santa Ysabel Creek, developed during the investigation reported in Bulletin No. 55, were utilized in this investigation. These hydrographs are considered to still be applicable inasmuch as no large floods have occurred since publication of Bulletin No. 55 in 1949. Bulletin No. 55 also contained considerable information on flood frequencies. Data on magnitudes and frequencies of floods of the San Dieguito River used in this investigation were taken from that report.

Reduction of peak discharges by operation of existing Sutherland

Reservoir were considered to be negligible; reduction of discharges by

existing Hodges Reservoir, considering surcharge storage above spillway crest,

was considered only for the purpose of evaluating damages which would occur

with existing facilities.

The only overflow areas considered in detail were those in the San Dieguito and San Pasqual Valleys. The type and estimated value of property and the acreage involved in each of these overflow areas are presented in Table 35.

ESTIMATED AVERAGE VALUE OF PROPERTY SUBJECT TO DAMAGE BY UNCONTROLLED FLOODS IN PRINCIPAL OVERFLOW AREAS IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1958 THROUGH 2007^a

		:	:	: Estimated
		: Approximate		:average prop-
	Type of property	:area, in 195		: erty value
	subject to flood damage	: in acres	:value, in 1958	
		:	•	: 50 years
Con	Diomaite Weller			
	Dieguito Valley gricultural:			
ı.	(a) Land and improvements	2,068	\$1,068,000	\$1,147,000
	(b) Crops (including pasture)	ъ	303,000	552,000
R	Residential	90	2,080,000	3,120,000
	airgrounds and racetrack	119	3,700,000	5,550,000
	irport	15	400,000	600,000
I	industrial	68	125,000	193,000
٧	acant urban	18	72,000	36,000
W	ells and water systems	ъ	204,000	247,000
Н	lighways, streets, and bridges	180	900,000	1,350,000
	ailroads and bridges	20	300,000	300,000
	filities	ъ	300,000	450,000
	hannel improvements	р	20,000	31,000
M	iscellaneous	422	10,000	10,000
	TOTAL	3,000	\$9,482,000	\$13,586,000
	IOIAD	3,000	φ2, 402,000	φ±3,700,000
San	Pasqual Valley			
	gricultural:			
•	(a) Tand and improvements	2,000	\$1,370,000	\$ 1,545,000
	(b) Crops (including pasture)	c	240,000	480,000
Į.	Wells and irrigation systems	c	150,000	225,000
	lighways and bridges	80	400,000	600,000
	itilities	С	85,000	128,000
M	liscellaneous	320	20,000	20,000
	TOTAL	2,400	\$2,265,000	\$ 2,998,000

a. Based on property and flood damage data developed by the United States Army Corps of Engineers.

b. Included in other area classifications of San Dieguito Valley over-flow area.

c. Included in other area classifications of San Pasqual Valley over-flow area.

Basic property and flood damage data for these two areas, developed by the United States Army Corps of Engineers from property appraisals and flood damage surveys and presented in the 1956 report, were revised for use in estimating the damages from future floods. Development in the overflow areas from 1956 through 1958 and estimates of future development during the 50-year period from 1958 through 2007, based on the latest available forecasts on future trends of development, including population forecasts, were considered in making the revisions.

Flood control benefits may be defined as the difference between the value of damages that would occur with and without the reservoir projects considered for construction in this report. The damages without each project were assumed to be those damages that would occur with existing Hodges Reservoir in operation and full to spillway crest at the beginning of each flood.

The estimated damages that would occur under the operation of either Pamo "B", San Pasqual, or Super Hodges Reservoirs were determined under two conditions of reservoir storage for each structure. One condition assumed that each reservoir would be full to spillway crest at the beginning of the flood period. Under such an operation, outflow from the reservoir would be reduced by surcharge storage above the spillway crest elevation. The second condition was based on the assumption that the storage capacity which remained unused on April 1, 50 per cent of the time, could have been used for flood control purposes earlier in the season. April 1 is considered the end of the flood season, when reservoirs in the watershed would generally have a minimum amount of unused storage capacity available.

Comparison of Flood Control Accomplishments

Floods with magnitudes of 10,000 second-feet or less generally cause little, if any, damage along the San Dieguito River. Flood magnitudes that exceed 10,000 second-feet cause damage approximately in proportion to the magnitude of the flood. Frequency curves for uncontrolled peak flows at potential reservoir sites are shown on Figure 1, Plate 21. The amount and frequency of occurrence of available storage capacity on April 1, in each of the three potential reservoirs, is shown on Figure 2, Plate 21.

The effect of each reservoir on floods of different recurrence intervals is set forth in Table 36. The regulating effect of surcharge storage on reduction of flood discharges at potential reservoirs, and the effect of surcharge storage, when combined with April 1 conservation storage space available 50 per cent of the time, are shown graphically on Figures 3, 4, and 5 of Flate 21.

TABLE 36

EFFECT OF POTENTIAL CONSERVATION RESERVOIRS ON FLOOD MAGNITUDES AND FREQUENCIES IN SAN DIEGUITO RIVER WATERSHED

	6	:Available	:			
	2	: storage	:			
		: capacity				
Reservoir and con-	: storage	: occurring		ndicated	flood re	currence
dition under which	: capacity a	t:50 per cent	t: i	nterval,	in years	S
discharge occurs	: spillway	of the time	:			
	: crest, in	on April 1,	:	:	•	
	: acre-feet	: in	: 5	2 5	: 100	1000
	0	: acre-feet	:	:	:	:
	7(0.100	0 000				
Pamo "B"	163,400	8,000				
(1) Uncontrolled						
flood flows at			70 (00		(5.000	701 000
dam site			12,600	39,200	67,200	124,000
(2) Spillway discharges						
when floods con-						
trolled by surcharge						
storage above spill-						
way crest only			4,800	19,800	37,200	75,400
(3) Spillway discharges						
when floods con-						
trolled by surcharge						
storage above spill-						
way crest and avail-						
able storage capacity	•					
occurring 50 per cent	,					
of the time on April	1		1,200	16,800	35,400	74,500
(4) Resultant outflow						•
from existing Hodges						
Reservoir considering						
surcharge storage						
above spillway crest						
only in Pamo "B" Res-						
ervoir			7,200	31,700	63,200	129,500
(5) Resultant outflow			. y	J-9100	-,,	
from existing Hodges						
Reservoir considering						
surcharge storage	•					
above spillway crest						
and available storage						
capacity occurring						
50 per cent of the						
time on April 1 in						
Pamo *B* Reservoir			1, 000	30,000	67 900	128,500
I die D Hooel voll			4,000	المال و المال	01,700	120,000

FFECT OF POTENTIAL CONSERVATION RESERVOIRS ON FLOOD MAGNITUDES AND FREQUENCIES IN SAN DIEGUITO RIVER WATERSHED (continued)

Reservoir and condition under which discharge occurs	: storage	:Available : storage : capacity : occurring t:50 per cent :of the time :on April 1, : in : acre-feet	for in	ndicated nterval,	e, in second reconding years	ond-feet, currence
San Pasqual (1) Uncontrolled flood flows at dam site (2) Spillway discharges when floods controlle by surcharge storage		80,000	12,500	. կ1,700	80,000	147,000
above spillway crest only (3) Spillway discharges when floods controlle by surcharge storage above spillway crest and available storage capacity occurring 50	ed.		և, 700	25,500	54,500	109,300
per cent of the time on April 1. (4) Resultant outflow from existing Hodges Reservoir considering surcharge storage above spillway crest only in San Pasqual	.		0	0	25,000	85,000
Reservoir (5) Resultant outflow from existing Hodges Reservoir considering surcharge storage above spillway crest and available storage capacity occurring 50 per cent of the time			4,800 *	26,700	58,700	109,400
on April 1 in San Pasqual Reservoir			0	3,000*	26,000	85,500*

EFFECT OF POTENTIAL CONSERVATION RESERVOIRS ON FLOOD MAGNITUDES AND FREQUENCIES IN SAN DIEGUITO RIVER WATERSHED (continued)

Reservoir and con- dition under which discharge occurs	storagecapacity aspillway	t:50 per cent	for		d flood	econd-feet, recurrence rs
	acre-feet	<pre>:on April 1, : in : acre-feet</pre>	: 5	25	100	1000
Super Hodges (1) Uncontrolled flood flows at dam site (2) Spillway discharges when floods controlled by surcharge storage	365,000	120,000	13,500	45 , 900	88,400	163,200
above spillway crest only (3) Spillway discharges when floods controlled by surcharge storage above spillway crest and available storage capacity occurring	đ		4,300	19,600	45,000	9 4, 600
50 per cent of the time on April 1			0	0	6,500	62,000

^{*} Interpolated figures

The effect of Pamo "B" Reservoir on floods of various magnitudes in San Pasqual and San Dieguito Valleys, considering surcharge storage only and considering both surcharge and available reservoir storage occurring 50 per cent of the time on April 1, is illustrated on Figure 6, Plate 21. Similarly, the effect of San Pasqual and Super Hodges Reservoirs on floods of various magnitudes in the San Dieguito Valley under the same conditions is shown on Figures 7 and 8, respectively, on Plate 21.

The relationship between peak discharges and damage from floods of various magnitudes in the San Dieguito and San Pasqual Valleys, based on flood damage data developed by the United States Army Corps of Engineers, was estimated for average conditions of development for the 50-year period, 1958 through 2007, and is shown on Figure 1, Plate 22.

The flood control benefits that would result under each type of operation, for each reservoir considered, would be equal to the difference between the monetary losses from flood damage occurring under existing conditions and the losses occurring under each type of operation, based on the average value of properties in the overflow areas involved during the 50-year period from 1958 through 2007. The damage-frequency relationship for floods of various frequencies in San Pasqual and San Dieguito Valleys under existing conditions of protection is shown on Figures 2, 3, 4, and 5, Plate 22, and was obtained by combining the data represented by the damage-discharge curves shown on Figure 1, Plate 22, with the data represented by the frequency of discharge curves in Figure 1, Plate 21, adjusted for effect of surcharge storage in existing Hodges Reservoir.

The damage-frequency relationships for floods of various frequencies in San Dieguito Valley, considering surcharge storage only and also considering both surcharge storage and the available storage space occurring 50 per cent of the time on April 1, in Pamo "B", San Pasqual, and Super Hodges Reservoirs, are shown on Figures 2, 3, and 4, respectively, of Plate 22. These relationships were derived by combining discharge-frequency data represented by the two lower curves on Figure 6 and the curves on Figures 7 and 8, Plate 21, with damage-discharge data represented by the upper curve on Figure 1, Plate 22. Similarly, damage-frequency relationships of floods of various frequencies in San Pasqual Valley, considering the two afore-mentioned reservoir storage conditions for Pamo "B" Reservoir are shown on Figure 5, Plate 22. These relationships were developed by combining data represented by the two upper curves on Figure 6, Plate 21, with corresponding data represented by the lower curve on Figure 1, Plate 22.

The area between the damage-frequency curves representing existing conditions of flood control and the damage-frequency curves for each of the two storage conditions, for each of the three reservoirs considered, represents the estimated average benefit that would accrue under each storage condition. The estimated average annual benefit attributable to each of the three potential conservation reservoirs are presented in Table 37 and shown on Figure 6, Plate 22.

FLOOD CONTROL DAMAGES AND BENEFITS RESULTING FROM OPERATION OF POTENTIAL CONSERVATION RESERVOIRS IN SAN DIEGUITO RIVER WATERSHED

Average annual damages, sensitis, in dollarsa in dollars existing structures; existing structures and indicated and indicated structures: consider: structures structures: consider: surcharge storage and indicated structures: storage and indicated structures: storage and indicated storage and indicated storage and structures: charge storage and ing sur-storage and structures: charge storage oc-storage storage storage only storage storage oc-storage storage storage oc-storage storage storage oc-storage storage storage oc-storage storage storage storage storage oc-storage storage storage storage oc-storage storage stor	\$ 35,400	\$119,400	222,000	246,500
Average annual damages, : Average annual in dollars : benefits, in dollars : with operation of : With operation of : with operation of : existing structures and indicated : and indicated : future structures : consider: : Consider: : Consider: : surcharge : Consider: : surcharge existing : ing sur- : storage and : storage : storage only : per cent of : time on : time on : April 1 :	\$ 31,500	\$ 93,500	102,300	150,000
annual damages, shenefits With operation of with of existing structures existing and indicated and future structures; future :Considering: Considering: consider surcharge consider and sur-storage and ing surcharge storage oc-storage storage storage oc-storage only curring 50 only : per cent of: time on time on time on the storage only	\$ 13,600 165,000	\$178,600	27,000	2,500
Average annual damages, in dollars : With operation : existing structuoper. : future structuoper. : Consider surch sting ing sur storage storage ctures: charge storage storage in storage st	\$ 17,500	\$204,500	146,700	000,66
Mith oper.: with oper.: with oper.: with of: Consider existing: ing sur- structures: charge only: storage only:	\$ 49,000	\$298,000	249,000	249,000
Principal overflow areas in which damage occurs	San Pasqual Valley San Dieguito Valley		San Dieguito Valley	San Dieguito Valley
Total storage storage storage capacity capacity ccurring at spillway: 50 per cent crest, in of time on acre-feet April 1, in:	8,000		80,000	120,000
Total storage capacity at spillway crest, in acre-feet	163,400		335,000	365,000
Reservoir	Pamo "B"	Totals	San Pasqual	Super Hodges

in operation minus average annual damages with existing and future structures in operation. Average annual benefits are equal to total average annual damages with existing structures ಥ

It is evident that greater benefits would result from construction and operation of the conservation reservoirs considered in the downstream portions of the watershed, makely, at the San Pasqual and Super Hodges sites. Estimated flood control benefits which could be realized from operation of the largest size Super Hodges Reservoir, considering surcharge storage only, are approximately one and one-fourth times the estimated benefits achieved from operation of the largest size Pamo Reservoir, considering both surcharge storage and overlable storage capacity occurring 50 per cent of the time on April 1.

The Congress has authorized the construction of a 375,000 acrefoot multiple-purpose reservoir at the Super Modges site, with a Federal
contribution of \$1,961,000. Using the separable costs-remaining benefits
method of cost allocation, the U.S. Any Corpo of Engineers estimates the
total flood control allocation for this project to be \$5,330,000, with
\$1,961,000 attributable to the dan proper and \$2,369,000 attributable to lands
and relocations. The Corps of Engineers reported that because the project
is local in nature with respect to Elocal control, the Sederal contribution
would be limited to \$1,961,000, or the first cost of the flood control
features of the dam.

Official views of the State of Califfornia on the project, transmitted to the Chief of Engineers on June 4, 1957, recommended that the federal contribution be \$4,330,000.

The present worth of the average amount benefits shown in Table 37 for a 365,000 acre-foot capacity conservation reservoir at the Super Hodges site, on the basis of a repayment period of 50 years with interest at a

rate of three and one-half per cent per annum, considering, first, surcharge storage only and, secondly, surcharge storage combined with available storage space occurring 50 per cent of the time on Noril 1, is estimated to be \$3,517,000 and \$5,779,000, respectively. It is evident that appreciable flood control benefits would be realized, and a major share of the need for flood control in the watershed would be satisfied, by the construction and operation of large water conservation reservoirs.

A discussion of individual projects for the control and development of surface and ground water supplies within the San Dieguito River watershed, including the anticipated yields to be developed and project costs, was presented in Chapter IV, entitled "Plans for Water Development". Individual projects, and combinations of projects, described in Chapter IV, are compared in this chapter primarily on the basis of seasonal yield, capital and annual costs, and cost per acre-foot of yield. They are also discussed from the aspect of inherent qualitative advantages and disadvantages. Through such comparisons of project combinations, the interrelationships between individual developments and the net effect on costs and yields of the various plans considered are accentuated. The desirability of stage development of the water resources of the watershed is also reported on in this chapter.

The final selection of the project to be constructed will, of necessity, be influenced by present and future need for development of additional water supplies considering availability of other local and imported water supplies, cost of water developed within the San Dieguito River watershed in relation to cost of water from other sources, and the ability and willingness of the City of San Diego, or other agencies, to finance the construction and operation of the water development facilities.

Development of San Pasqual-Main Lake Hodges Ground Water Basin

Additional ground water supplies through development of San Pasqual-Main Lake Hodges Basin could be made available almost immediately,

in contrast to the probable delay which would be encountered in securing equivalent supplemental supplies from surface storage facilities. In semiarid San Diego County, where lengthy periods of drought are often experienced, five or ten years might elapse before the safe yield could be obtained from surface storage.

Ground water is not as readily susceptible to evaporation losses as water stored in surface reservoirs. Although high ground water levels generally result in increased phreatophyte growth and water losses, the average ground water levels during a mean period under planned basin operation would be considerably lower than under present conditions.

The major disadvantage associated with developing additional ground water yield from the San Pasqual—Main Lake Hodges Basin is that the underground storage capacity cannot normally be filled as fast as water becomes available since replenishment is dependent on the infiltration rate of the surficial material and the permeability of the underlying sediments.

The proposed utilization of San Pasqual-Main Lake Hodges Basin would result in a maximum ground water storage depletion of \$\pm\1,000\$ acrefeet. The basin, when operated coordinately with existing Sutherland and Hodges Reservoirs, would produce a net safe seasonal yield, creditable to the ground water basin, of about 5,800 acre-feet or about 2,600 acre-feet more than under present conditions of operation. It is assumed that the Sutherland-San Vicente Reservoir system would be operated so that a portion of the water which would have spilled from Sutherland Reservoir would be transferred to existing San Vicente Reservoir. This operation is hereinafter referred to as the "transfer of spill" operation. Without such an operation, the net safe seasonal yield creditable to the ground water basin would be approximately 6,000 acre-feet, as discussed in Chapter IV.

capital and annual costs of utilizing the maximum ground water storage capacity of 41,000 acre-feet of the San Pasqual-Main Take Hodges Basin are estimated to be \$6,160,000 and \$315,000, respectively, including the cost of lands now owned by the City of San Diego and conveyance facilities. The estimated combined net safe seasonal additional yield to the City of San Diego from operation of the basin and with transfer of spill to San Vicente Reservoir would be 5,800 acre-feet creditable to the ground water basin. The total cost to develop this additional yield is estimated to be about \$54 per acre-foot of new yield.

not developed for use on overlying and adjacent hilly lands, but was exported outside the watershed by the City of San Diego, it would probably be necessary for the City to acquire all lands within and adjacent to the basin or the water rights contiguous therewith. The City has purchased most of the lands within San Pasqual-Main Lake Hodges Basin. To determine the additional cost to the City of developing the largest usable ground water storage capacity, the value of all lands and improvements not presently owned by the City and required by the project was estimated.

It is understood that the City is negotiating with representatives of The San Pasqual Academy for the purpose of acquiring the right to the use of ground waters underlying the Academy. It has been assumed for cost estimating purposes that the City would acquire the Academy property as part of the ground water development.

If the value of lands and improvements now owned by the City of San Diego within the project area is deducted from the total project cost, the additional cost to the City for developing the largest usable ground water storage capacity considered herein, is estimated to be about \$34 per acre-foct of additional yield.

The City of San Diego reports it would probably purchase the remaining privately—owned land in San Pasqual—Main Lake Hodges Basin if the decision of the trial court, in the case of "Stanley Trussell, et al., plaintiffs, vs. The City of San Diego, a Municipal Corporation, defendant, is upheld on appeal. In this event, the cost of the acquisition of the remaining lands and improvements in the basin to permit unrestricted use of Sutherland Reservoir could be charged against the Sutherland Reservoir project and not against potential ground or surface water developments in the watershed. However, for purposes of this investigation, the cost of land acquisition in the basin was not charged against the Sutherland Reservoir project.

Accomplishments resulting from utilization of various ground water storage capacities in the San Pasqual-Main Lake Hodges Basin, and the capital and annual costs of developing additional yields are compared, in Table 38, with the accomplishments and costs of other plans of development. The relationship between ground water storage capacity and project capital cost for the ground water basin development are shown on Plate 23, while the relationship of storage capacity and additional safe seasonal yield is shown on Plate 24. The relationship between additional safe seasonal yield and annual cost per acre-foot of yield is presented on Plate 25. On the basis of these relationships and in recognition of the current financial investment by the City of San Diego in acquiring lands and improvements in San Pasqual-Main Lake Hodges Basin and the immediate availability for use of ground water in storage in the basin, it is assumed that San Pasqual-Main Lake Hodges Basin would be further developed and used in conjunction with spillway

gates on Sutherland Dam before, or simultaneously with, the construction of dams and reservoirs at the Pamo "B", or San Pasqual sites, or enlargement of San Vicente Reservoir.

Average incremental	annual in	cremental co 1 combined s	sts per acre afe seasonal	-foot of system yield
Reserv		: :	Tot	
to the City of	: : : Total	: :Conveyance: :facilities: :	Addi- tional cost to the City of San Diego	: Project total
			\$ 5.50 ^b	\$ 5.50 ^b 8.90 ^b
\$34.20 51.10	\$34.20 51.10	\$ 5.80 3.70	40.00 54.80	40.00 54.80
25.40 40.30	26.70 42.20	7.50 18.70	32 . 90 59 . 00	34.20 60.90
67.80 52.90	94.40 63.40	6.70 7.40	74.50 60.30	101.10

	: Oross reservoir : Combined safe ses-: :storage capacities,:sonal system yields,: : in acre-feet : in scre-feet :					Capital cost			:	Ave	rage annual c	esta		Average	Average annual costs per acre-foot of additional combined safe seasonal system yield tincremental additional combined				remental cos	oste per acre-foot of safe sessonal system yield				
		re-feet	in sc	e-feet	Reser	voir	_:	T	otals	Rese:	Reservoir		Totals		Reserve	oir	1 :	Totals			Reservoir		Tota	
Flan for devalopments within San Dieguito River watershed	: for : City of	: Total : for : City of o:San Diego	: Addi- : tional : : for : : use by : : City of : :San Diego:	for : use by : City of : San Diego:	Addi- : tional : cost : to the : City of : San Diego :	Total	Conveyance : facilities :	cost	: total	: Addi- t tional cost t to the City of San Diego	Total	: Conveyance : facilities	coet	Project : total :	tional cost to the	: Total	: :Conveyance: :facilities:	tional eost	: Project : total :	tional cost	: Total :	Conveyance: facilities:	cost	: Project : total
1. Hodges Reservoir, capacity: 33,550 acre-feet Sutherland Reservoir, capacity: 29,080 acre-feet Exacting San Yicente Reservoir, capacity: 5,300 acre-feet San Pasqual-Main Lake Hodges Resin, capacity: 13,700 acre-feet	13,700	82,230	3,200	12,300				\$ 3,460,400 ^b	\$ 5,966,800b				\$ 180,600 ^b	\$ 298,000 ^b				\$ 56.40 ^b	\$ 93.10 ^b				\$ 5.50 ^b	
27,000 acre-feet	27,000	95,530	4,700	13,800				3,537,100b	6,043,500b				188,900 ^b	306 ,3 00 ⁶				40.20 ^b	65.20b					
41,000 acre-feet	000, تبا	109,530	5,800	14,900				3,657,300b	6,163,700 ^b				198,700 ^b	316,100 ^b				34.30b	54.50b				8.90 ^D	5.90 ^b
2. Hodges Reservoir, capacity: 33,550 acro-feet Suthorland Reservoir, capacity: 29,600 acro-feet Existing San Vicente Reservoir, capacity: 5,300 acro-feet Admitton of spillway gates at Sutherland Reservoir, capacity: 7,750 acro-feet	7,750	76,280	600	9,700		\$ 243,500			243,500		\$ 12,400			12,400		\$ 20.70			20.70					
 Hodges Reservoir, capacity: 33,550 acre-feet Sutherland Reservoir, with spillway gates, capacity: 37,430 acre-feet Existing San Viesente Reservoir, capacity: 5,300 acre-feet San Pasqual-Main Lake Hodges Besin, capacity: 11,000 acre-feet Pamo Reservoir. 																								
capacity: 90,000 acre-feet	138,750	207,280	9,800	18,900	\$11,366,500	13,933,900	\$3,361,200	Ш,727,700	17,295,100	\$ 572,200	692,400	\$160,800	733,000	853,200	\$ 58.40	70.70	\$16.40	74.80	87.10	\$34.20	#31. 30	\$ 5.80	40.00	h0.00
135,000 acre-feet	183,750	252,280	12,200	21,300	13,053,100	15,620,500	3,652,600	16,705,700	19,273,100	654,400	774,600	174,700	829,100	949,300	53.60	63.50	14.30	67.90	77.80					
163,400 acre-feet	212,150	280,680	13,800	22,900	14,761,800	17,329,200	3,775,900	18,537,700	21,105,100	736,100	856,300	180,700	916,800	1,037,000	53.30	62.00	13,10	66.40	75.10	51.10	51.10	3.70	54.80	54.80
4. Hodges Reservoir, capacity: 33,550 acre-feet Sutherland Reservoir, with spillway gates, capacity: 37,130 acre-feet Existing San Vicente Reservoir, capacity: 5,300 acre-feet ⁸ San Pasqual Reservoir, including use of 37,000 acre-feet of ground water storage capacity within the reservoir area, total capacity: 137,000 acre-feet	144,750	213,280	8,700	17,600	12,599,800	1h,437,800	1,530,200	14,130,000	15,968,000	606,500	692,500	101,600	708,100	794,100	69.70	79.60	11.70	81.40	91•30	25.10	26,70	7.50	22.00	¥20
257,000 acre-feet	264,750	333,280	14,200	23,300	15,414,200	17,407,200	1,946,900	17,361,100	19,354,100	746,200	839,600	142,600	888,800	982,200	52.50	59.10	10.10	62.60	69.20	25.40			32.90	
372,000 acre-feet ^d	379,750	880,544	18,400	27,500	18,879,400	21,051,400	2,342,900	21,222,300	23,394,300	915,400	1,017,100	221,000	1,136,400	1,238,100	49.80	55.30	12.00	61.80	67.30	цо. 30	42.20	18.70	59.00	60.90
 Sutherland Reservoir, with spillway gates, capacity: 37,430 acre-feet Existing San Vicente Reservoir, capacity: 5,300 acre-feet 																								
Super Hodges Reservoir, capacity: 157,300 acre-feet ⁶	131,500	200,030	4,600	13,700	13,933,500	19,364,200	921,600	14,855,100	20,285,800	669,300	923,700	67,000	730,300	990,700	145.50	200.80	14.60	160.10	215.40					
310,000 acre-feet ef	284,200	348,830	11,300	20,400	23,141,300	32.678.900	1,307,000	24,748,300	33,985,900	1,123,800	1,556,400	111,600	1,235,400	1,668,000	99.40	137.70	9.90	109.30	147.60	67.80	94.40	6.70	74.50	
365,000 acre-feet ^{eg}		402,430	-	22,600	25,851,900	35,583,400		27,317,600	37,049,100		1,695,800	128,000	1,368,100	1,823,800	91.80	125.60	9.50	101.30	135,10	52.90	63.40	7.40	60,30	70.80

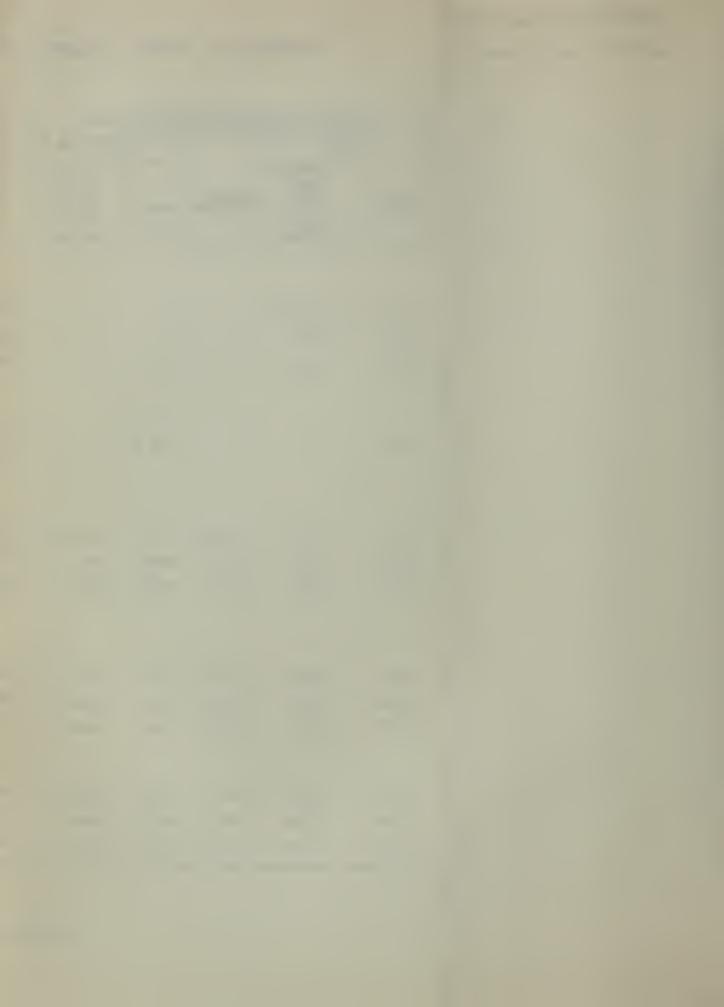
s. Utilizing 5,300 acre-feet of storage capacity in existing San Vicente Reservoir that is not needed to regulate natural runoff of San Vicente Creek and the estimated 1975 imports to the City of San Diego through the First San Diego Aqueduct.
b. Includes cost of conveyance facilities from San Pasqual-Main Lake Hodges Reservoir.
c. Assumes present Law uses in San Pasqual-Main Lake Hodges Resin and coordinate operation of Hodges and Sutherland Reservoirs with transfer of spills to San Vicente Reservoir.
d. Required storage capacity in existing San Vicente Reservoir to reregulate transferred spills is only 900 acre-feet.
e. Assumes present Laud and water use in the portion of San Pasqual-Main Lake Hodges Resin which would not be inumbed to be foundated by Super Hodges Reservoir and coordinate operation of Sutherland and Super Hodges Reservoire with transfer of spills to San Vicente Reservoir.
f. Required storage capacity in existing San Vicente Reservoir to reregulate transferred spills is only 1,000 acre-feet.
No additional storage capacity required at cristing San Vicente Reservoir.

Potential Surface Storage Developments

There are several potential surface water development facilities which might be constructed in the San Dieguito River and adjacent watersheds. Each of these developments would serve to provide additional safe seasonal yield, over and above that of the existing development. The potential developments include the provision of storage at Pamo "B", San Pasqual, or Super Hodges sites in conjunction with the addition of spillway gates to the existing Sutherland Dam, and a proposed enlargement of San Vicente Reservoir in the San Diego River watershed.

Addition of Spillway Gates on Sutherland Dam

The installation of spillway gates on Sutherland Dam would increase the combined net safe yield of Sutherland and Hodges Reservoirs when operated coordinately, from 9,100 acre-feet to 9,700 acre-feet per season, under present conditions of ground water development and with "transfer of spill" operation of Sutherland and existing San Vicente Reservoirs. The estimated capital cost of developing the 600 acre-feet of new yield would be \$243,500, equivalent to an average annual cost of about \$21 per acre-foot of new yield. It is assumed that the City of San Diego would add gates whenever the reservoir stage becomes high enough to assure their use. Spillway gates at Sutherland Dam are, therefore, assumed to be installed when considering alternative developments at the Pamo "B", San Pasqual, and Super Hodges sites.



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Storage, yield, and cost relationships associated with installation of spillway gates on Sutherland Dam are presented in Table 38. Plates 23,24, and 25 contain illustrative data pertaining to these relationships.

Pamo "B" Reservoir

Cost of right of way and road and utility relocation required for a surface storage development at the Pamo "B" Reservoir site would be appreciably lower than such costs for projects at the San Pasqual and Super Hodges Reservoir sites. Furthermore, releases from Pamo "B" Reservoir could be conveyed to the proposed Miramar Reservoir of the City of San Diego by gravity flow, whereas, the remaining alternative surface reservoir plans would require pumping facilities. The length of pipe line required for the Pamo development, however, would be more than twice the length of the conduit needed for diversion from San Pasqual or Super Hodges Reservoirs.

Reservoirs at the Pamo "B" site would produce a greater new yield per acre-foot of storage capacity than either San Pasqual or Super Hodges Reservoirs; however, even the largest reservoir considered at the Pamo "B" site, with a capacity of 163,400 acre-feet, does not control a sufficient portion of the watershed runoff to effect complete water development. This condition is true even with coordinate safe yield operation of San Pasqual-Main Lake Hodges Basin and existing surface storage facilities. In view of the water supply situation in the San Dieguito River watershed, it was assumed for purposes of determining cost-yield relationships for a development at the Pamo "B" site that the City would purchase all the lands in San Pasqual Valley and the costs thereof would be a charge against the Pamo "B" project. It was, therefore, also assumed that the City would further develop the ground water supplies within San Pasqual-Main Lake Hodges Basin

and that the new yield resulting therefrom would be added to the yield from the Pamo "B" project to increase the combined system yield.

Three capacities for Pamo "B" Reservoir were considered which would provide incremental seasonal yields ranging from 3,600 to 7,600 acrefeet in excess of that which could be obtained from utilization of \$\frac{1}{4}\frac{1}{2},000\$ acrefeet of ground water storage capacity in San Pasqual-Main Lake Hodges Basin, in conjunction with spillway gates on Sutherland Dam, and with the "transfer of spill" operation between Sutherland and existing San Vicente Reservoirs. These incremental yields could be developed at an additional average annual unit cost to the City of San Diego varying from \$145 to \$93 per acre-foot, as derived from Tables 31 and 38.

The flood control benefits accrued from operation of Pamo "B"

Reservoir, although substantial, would be less than the benefits achieved from operation of either San Pasqual or Super Hodges Reservoirs.

The capital and annual costs of the largest size reservoir considered at the Pamo "B" site, having a storage capacity of 163,400 acrefeet, together with spillway gates on Sutherland Dam and utilization of 41,000 acrefeet of ground water storage capacity in San Pasqual-Main Lake Hodges Basin, are estimated to be \$21,105,100 and \$1,037,000, respectively, including cost of conveyance facilities. The estimated combined net safe seasonal additional yield to the City of San Diego from the system, creditable to these three developments, assuming a "transfer of spill" operation of Sutherland and existing San Vicente Reservoirs, is 13,800 acre-feet. The total cost to develop this additional yield is estimated to be about \$75 per acre-foot of new yield. Since the City of San Diego already owns land within the Pamo "B" project area and San Pasqual Valley, the estimated additional cost to the City for these developments would be about \$66 per acre-foot of new yield.

Total and new system yields for various storage capacities of Pamo "B" Reservoir and the capital and annual costs of developing these new yields are compared with storages, yields, and costs of other plans of development in Table 38. The relationship between storage capacity and project capital cost for the project is shown on Plate 23, and that between storage capacity and additional safe seasonal yield is shown on Plate 24. The relationship between additional safe seasonal yield and annual cost per acre-foot of yield is presented on Plate 25.

San Pasqual Reservoir

A reservoir at the San Pasqual site would control most of the runoff from the watershed. The largest reservoir considered at the San Pasqual site would produce somewhat greater flood control benefits than the largest reservoir considered at the Pamo "B" site but somewhat less than the benefits which would be achieved at the Super Hodges site.

The static pumping lift between a development at the San Pasqual site and proposed Miramar Reservoir of the City of San Diego would be approximately 363 feet, whereas water diverted from Pamo "B" Reservoir would flow to Miramar Reservoir by gravity.

Development of the San Pasqual site could involve extensive relocation of State Highway No. 78 from the City of Escondido to the community
of Ramona if a route along the northerly border of San Pasqual Valley
generally paralleling the present route, was adopted. The present route
was added to the State highway system by legislative act. However, it is
estimated that the highway could be rerouted at considerably less cost if
the existing bridge on U. S. Highway No. 395 across the San Dieguito River
was used. The route to Ramona would then extend southeasterly through
Green Valley to join State Highway No. 67 at a point near Woodson Mountain.

This routing of State Highway No. 78 would require about three miles of new road and the cost would be about one-tenth the cost of the northerly relocation. The State Division of Highways reports that action by the State Legislature would be required before a route through Green Valley could be adopted.

Three sizes of development at the San Pasqual site, including 37,000 acre-feet of ground water storage capacity within the reservoir area, were considered which would provide incremental seasonal yields ranging from 2,500 to 12,200 acre-feet in excess of that which could be obtained from utilization of 41,000 acre-feet of ground water storage capacity in San Pasqual-Main Lake Hodges Basin, in conjunction with spillway gates on Sutherland Dam, and with the "transfer of spill" operation between Sutherland and existing San Vicente Reservoirs. These incremental yields could be developed at an additional average annual unit cost to the City of San Diego varying from \$199 to \$76 per acre-foot, as derived from Tables 31 and 38.

The capital and annual costs of the largest size reservoir considered at the San Pasqual site, with a storage capacity of 335,000 acrefeet, together with spillway gates on Sutherland Dam, are estimated to be \$23,394,300 and \$1,238,100, respectively, including cost of conveyance facilities and the development of 37,000 acrefeet of ground water storage capacity available within the reservoir area. Such a plan of development would conserve about 60 per cent of the present waste to the ocean from the San Dieguito River. The estimated combined net safe seasonal additional yield to the City of San Diego from the system for these

developments, assuming a "transfer of spill" operation of Sutherland and existing San Vicente Reservoirs, is 18,400 acre-feet, and the total cost to develop this additional yield is estimated to be about \$67 per acre-foot of new yield. Since the City of San Diego now owns land within the project area, the additional cost to the City for this development would be approximately \$62 per acre-foot of new yield.

Yields from these developments for various storage capacities of San Pasqual Reservoir and the capital and annual costs of developing these new yields are compared with yields and costs of other plans of development in Table 38. Relationships between storage capacity, yield, and cost are shown on Plates 23, 24, and 25.

If coordinate operation of surface and ground water storage were initiated at the San Pasqual site subsequent to development of the San Pasqual-Main Lake Hodges Basin, the well pumping equipment and distribution system existing at that time in the basin and within the surface reservoir area would require substantial and costly modification, whereas, no such modification would be necessary as a result of subsequent stage development at the Pamo "B" site.

Super Hodges Reservoir

Super Hodges Reservoir, created by construction of a dam just downstream from existing Hodges Dam, would control runoff from a larger drainage area than reservoirs at the Pamo "B" or San Pasqual sites and, therefore, would effect the greatest reduction of waste to the ocean.

However, Super Hodges Reservoir is subject to high evaporation losses

per acre-foot of storage. Additionally, the first 33,550 acre-feet of storage provided would merely replace the storage in existing Hodges

Reservoir. For these reasons, new yields from the Super Hodges Reservoir development would be somewhat less than those capable of development from either Pamo "B" or San Pasqual Reservoirs with comparable storage capacities. Due to its location and storage capacity, the greatest flood control benefits of any of the three alternative surface storage plans considered would be achieved from a reservoir at the Super Hodges site.

Super Hodges Dam would be located at a lower elevation than either San Pasqual or Pamo "B" Reservoirs. The static pumping lift between Super Hodges Dam and the proposed Miramar Reservoir would be approximately 445 feet.

Costs of highway relocation for a project at the Super Hodges site would be substantially greater than similar costs for developments at the Pamo "B" or San Pasqual sites and would amount to approximately 13 million dollars for the 365,000 acre-foot capacity reservoir. The major component of this cost would be caused by the necessary modification of a four-lane bridge and approaches, scheduled for construction in the next few years, on U. S. Highway No. 395. However, the cost to the City of San Diego of modifying U. S. Highway No. 395 as a result of construction of a dam and reservoir at the Super Hodges site would be based on the existing two-lane highway, as provided in an agreement dated May 27, 1954, between the City and the State Division of Highways. A copy of this agreement is included in Appendix K.

Costs of lands and improvements within the Super Hodges Dam and Reservoir area, other than that required for highway relocation, would also be considerably greater than for either of the two alternative surface storage projects and would amount to about \$7,000,000 for the 365,000 acre-foot capacity reservoir.

Capital and annual costs of the largest size dam and reservoir considered at the Super Hodges site, with a storage capacity of 365,000 acre-feet, together with spillway gates on Sutherland Dam, are estimated to be \$37,049,100 and \$1,823,800, respectively, including cost of conveyance facilities. This does not include the cost of coordinate use of 41,000 acrefeet of ground water storage capacity within San Pasqual-Main Lake Hodges Basin. This latter cost was not considered as it was apparent that prospective new yield from ground water development, amounting to about 4,700 acre-feet per season, even if secured at no additional cost, would not alter the cost-yield relationship for the Super Hodges project to such a degree as to make it competitive with other conservation developments considered herein.

The estimated combined net safe seasonal additional yield to the City of San Diego from this plan, excluding development of 41,000 acre-feet of ground water development, but including an assumed "transfer of spill" operation of Sutherland and existing San Vicente Reservoirs, is 13,500 acrefeet, and the total cost is estimated to be about \$135 per acre-foot of new yield. If the value of lands now owned by the City of San Diego within the project area and the cost of non-City modification of U. S. Highway No. 395 are deducted from the project cost, the additional cost to the City for this development would be approximately \$101 per acre-foot of new yield.

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Yields for various storage capacities of Super Hodges Reservoir and the capital and annual costs of developing these new yields are compared with yields and costs of other plans of development in Table 38. The relationships between storage capacity, yield, and cost are shown on Plates 23, 24, and 25.

San Vicente Reservoir

Comparison of potential ground and surface water developments previously discussed in this chapter has been confined to those projects which would be constructed within the San Dieguito River watershed. During periods of spill from all reservoirs in the San Dieguito River watershed, it would be feasible to increase the diversion from Sutherland Reservoir to San Vicente Reservoir. This would entail the temporary diversion of a quantity of water considerably in excess of the amount diverted under the proposed system of safe yield operation of existing reservoirs within the watershed only. For the same reasons, such diversions could also be made, although in smaller amount, with one of the potential alternative plans considered for construction in the San Dieguito River watershed. This method of operation has the advantage of making water which would have wasted to the ocean under a safe yield operation of facilities within the San Dieguito River watershed available to the City of San Diego through the existing facilities. The magnitude of diversions from Sutherland Reservoir to San Vicente Reservoir, in excess of that possible under a combined system safe yield operation, becomes progressively less as storage is increased within the San Dieguito River watershed, as set forth in Table 31. No appreciable flood control benefits in the San Dieguito River watershed would result from conservation effected by an enlarged San Vicente Reservoir.

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System yield from this operation could thus be increased without additional cost to the City, due to the estimated available storage
capacity in San Vicente Reservoir under 1975 conditions of import. This
capacity, however, will not be sufficient to reregulate all water which
would be available for diversion under existing conditions or, except
for the largest reservoirs, under potential alternative developments within
the San Dieguito River watershed. The City of San Diego, however, by a
reduction in the purchase of imported water from the San Diego County
Water Authority, and the coincident conservation and reregulation in San
Vicente Reservoir of an equivalent quantity of San Dieguito River watershed water, could effect a considerable monetary saving while maintaining
the total water supply as a constant quantity. Table 32 illustrates the
results of an operation of this type.

After utilization of 41,000 acre-feet of underground storage capacity in San Pasqual-Main Lake Hodges Basin, together with installation of spillway gates on Sutherland Dam, the next least costly increment of additional yield, to a maximum of 3,600 acre-feet per season, could be obtained by diversion of flood flows from Sutherland Reservoir to an enlarged San Vicente Reservoir, as derived from Tables 31, 38, and 39. The volume of water available for diversion to San Vicente Reservoir, however, becomes less as storage is increased within the San Dieguito River watershed. If developments were constructed at either the Pamo "B" or San Pasqual site after San Vicente Reservoir was enlarged, the unused storage capacity in San Vicente Reservoir resulting from the decrease in diversion from San Dieguito River watershed could be utilized for storage of imported water.

	Averag incremental	e annual in additional	ncremental cost	ts per acre-fo	ot of tem yield				
	Reser	voir	: _:	Totals					
	Addi- tional cost to the City of San Diego	Total	: Conveyance : facilities :	Addi- tional cost to the City of San Diego	: : Project : total :				
0					n = =				
	\$-2.20	\$- 2 . 20	\$ 9. 90	\$ 7.70	\$ 7.70				
	1.70	1.70	10.00	11.70	11.70				
	7.50	5.40	11.70	4.20	6.30				
	7.30	9.60	21.80	29.10	31.40				

COMPARISON OF YIELDS AND COSTS OF ALTERNATIVE PLANS FO AND ENLARGEMENT OF SAN

		Oross reservoir storage capacity : Combined safe : available to the City of San Diego, : seasonal system :						Capital costs					
		: in acre-feet :yield, in acre-fe											
		:	:	: tional	Total	:	:	Rese	voir	:	Т	otals	
	m2	: Addi-		: from San : Dieguito :		. 1444	: Total	Addi-	:	:	Addi-		
	Plan for developments within San Dieguito River watershed			: River				tional	:	:	tional		
				: watershed :						: Conveyance :		: Project :	
		:Reservoir		: develop- : ments and :						: facilities :	to the City of	: total :	
		:		:San Vicente:				: San Diego		:		:	
		:	:	: Reservoir :	Reservoir	:	: :	<u> </u>	:	: :	·	: :	
1.	Hodges Reservoir, capacity: 33,550 acre-feet Sutherland Reservoir. capacity. 29,680 acre-feet Portion of existing San Vicenta Reservoir utilized: 5,300 acre-feet	52,400	142,600	52,400	205,830	4,100	18,400	\$ 7,963,200	\$ 7,963,200	\$ O	\$ 7,963,200	\$ 7,96 3,2 00	
2.	Hodges Reservoir, capacity: 33,550 acre-feet Sutherland Reservoir, with spillway gates, capacity: 37,430 acre-feet Portion of existing San Vicente Reservoir utilized: 5,300 acre-feet San Pasqual-Main Lake Hodges Basin, capacity: 41,000 acre-feet	49,400	139,600	98,150	251,580	9,800	24,100				11,503,600 ^b	14,010,000 ^b	
3.	Hodges Reservoir, capacity: 33,550 acre-feet Sutherland Reservoir, with spillway gates, capacity: 37,430 acre-feet Portion of existing San Vicente Reservoir utilized: 5,300 acre-feet San Pasqual-Main Lake Hodges Basin, capacity: 41,000 acre-feet Pamo Reservoir.												
	capacity: 90,000 acre-feet	40,600	130,800	179,350	332,780	12,400	26,700	17,912,200	20,479,600	3,361,200	21,273,400	23,840,800	
	135,000 acre-feet	25,600	115,800	209,350	362,780	13,800	28,100	17,796,900	20,364,300	3,652,600	21,449,500	24,016,900	
	163,400 acre-feet	11,400	101,600	223,550	376,980	14,400	28,700	17,799,800	20,367,200	3,775,900	21,575,700	24,143,100	
4.	Hodges Reservoir, capacity: 33,550 acre-feet Sutherland Reservoir, with spillway gates, capacity: 37,430 acre-feet Portion of existing San Vicente Reservoir utilized: 5,300 acre-feet San Pasqual Reservoir, including use of 37,000 acre-feet of ground water storage capacity within the reservoir area, total capacity: 137,000 acre-feet	40 , 600	130,800	185,350	338,780	11,300	25,600	19,145,500	20,983,500	1,530,200	20,675,700	22,513,700	
	257,000 acre-feet	11,400	101,600	276,150	429,580	14,800	29,100	18,452,200	20,445,200	1,946,900	20,399,100	22,392,100	
	372,000 acre-feet ^c	0	90,200	379,750	533,180	18,400	32,700	18,879,400	21,051,400	2,342,900	21,222,300	23,394,300	

a. Assumes present land and water use in San Pasqual-Main Lake Hodges Basin and coordinate operation of Hodges and Sutherland reservoir with transfer of spills to San Vicente Reservoir.
b. Includes cost of conveyance facilities from San Pasqual-Main Lake Hodges Basin to Hodges Reservoir.
c. Required storage capacity to reregulate transferred spills is only 900 acre-fest.

PLANS FOR DEVELOPMENT WITHIN SAN DIEGUITO RIVER WATERSHED T OF SAN VICENTE RESERVOIR

: Average annual costs							Average annual costs per acre-foot of additional combined safe seasonal system yield						Average annual incremental costs per acre-foot of incremental additional combined safe seasonal system yield					
.s	Reservoir		:	Totals		Reservoir		:	Totale		Reservoir		: :	Totals				
	tional cost to the	:	: : : : : : : : : : : : : : : : : : :	to the City of	: : Project : total :	: Addi- : tional : cost : to the : City of : San Diego		: Conveyance : facilities :	to the	: : Project : total :	to the	: Total	: : : : : : : : : : : : : : : : : : :	tional cost to the City of San Diego	: Project : total			
7,963,200	\$376 , 000	\$ 376,000	\$ 0	\$ 376,000	\$ 376,000	\$ 91 . 70	\$91 .7 0	\$ 0	\$ 91 . 70	\$91.70								
14,010,000 ^b				570 ,100^b	687 , 500 ^b				58 .20 ^b	70:20 ^b								
23,840,800	881,100	1,001,300	160,800	1,041,900	1,162,100	71.00	80.70	13.00	84.00	93.70	\$- 2 . 20	\$-2.20	\$ 9. 90	\$ 7.70	\$ 7.70			
24,016,900 24,143,100	878,000 879,000	998 ,20 0 999 ,20 0	174,700 180,700	1,052,700 1,059,700	1,172,900	63.60 61.10	72.30 69.40	12.70 12.50	76.30 73.60	85.00 81.90	1.70	1.70	10.00	11.70	11.70			
22,513,700	915,400	1,001,400	101,600	1,017,000	1,103,000	81.00	88.60	9.00	90.00	97.60					(22			
22,392,100 23,394,300	889,100 915,400	982,500 1,017,100	142,600 221,000	1,031,700 1,136,400	1,125,100 1,238,100	60.10 49.80	66.40 55.30	9.60 12.00	69.70 61.80	76.00 67.30	7.50 7.30	5.40 9.60	11.70 21.80	4.20	6.30 31.40			



A brief discussion of an enlargement of San Vicente Reservoir for regulation of imported water is presented in Bulletin No. 61, "Feather River Project—Investigation of Alternative Aqueduct Routes to San Diego County", dated March, 1957. This importation would be over and above the estimated 1975 import to San Vicente Reservoir assumed in this report. Safe yields achieved by diverting from Sutherland Reservoir to an enlarged San Vicente Reservoir during times of spill from all reservoirs in the San Dieguito River watershed under the different plans of development are presented in Table 39.

Capital and annual costs of a 49,400 acre-foot enlargement of San Vicente Reservoir, spillway gates on Sutherland Dam, and utilization of 41,000 acre-feet of ground water storage capacity in San Pasqual-Main Lake Hodges Basin are estimated to be \$14,010,000 and \$687,500, respectively, including cost of conveyance facilities. The estimated combined net safe seasonal additional yield to the City of San Diego from the system, creditable to these developments, is 9,800 acre-feet.

The cost to develop this additional yield is estimated to be about \$70 per acre-foot of new yield. If the value of lands and improvements now owned by the City of San Diego within the project area is deducted from the project cost, the additional cost to the City would be approximately \$58 per acre-foot of new yield.

Total and new system yields for various storage capacities of San Vicente Reservoir and the capital and annual costs of developing these new yields are compared with storages, yields, and costs of other plans of development in Table 39. The relationship between storage capacity and project capital cost for the project is shown on Plate 23, and that between storage capacity and additional safe seasonal yield is shown on Plate 24. The relationship between additional safe seasonal yield and annual cost per acre-foot of yield is shown on Plate 25. On the basis of these relationships and values of yield presented in Table 34, it is apparent that to develop an additional system yield in excess of about 3,600 acre-feet per year, after development of San Pasqual-Main Lake Hodges Basin and addition of spillway gates on Sutherland Dam, it is more economical on the basis of the unit cost of new yield to construct, at a higher capital cost, a dam and reservoir at either the Pamo "B" or San Pasqual site, rather than to enlarge San Vicente Reservoir in conjunction with a development at either of these two sites in the watershed. Selection of the stages in the

plan of development will depend, therefore, on the amount of new yield required and the availability of funds to those agencies contemplating construction.

The following conclusions and recommendations result from the investigation of the water supply and requirements of the San Dieguito River watershed and the City of San Diego.

Conclusions

- 1. Mean seasonal runoff from the San Dieguito River watershed is about 43,400 acre-feet, of which approximately 26,300 acre-feet, or 61 per cent of the total, would waste to the ocean under present conditions of development.
- 2. The safe seasonal yield of present water supply development within the watershed is about 18,800 acre-feet, comprising 9,100 acre-feet from Hodges and Sutherland Reservoirs when operated coordinately with existing San Vicente Reservoir and 9,700 acre-feet from ground water basins. In addition, varying quantities of water are imported each year to the watershed from San Luis Rey River and through the San Diego Aqueduct. Under postulated "present" conditions, these imports amount to about 7,600 acre-feet per season.
- 3. Of the water supply developed within the watershed or imported thereto totaling 26,400 acre-feet per season, 19,500 acre-feet are available for use within the watershed and 6,900 acre-feet are for use in areas outside the watershed.
- h. Surface water supplies within the watershed are generally of good mineral quality except in the coastal area where saline tidal sloughs are found. The ground water resources in the watershed also are generally of good mineral quality, except in the San Dieguito ground water basin where high concentrations of dissolved minerals are found along the

coastal margin. Development of San Dieguito Basin has resulted in an over-draft on the limited supplies and has lowered ground water levels as much as 40 feet below sea level, permitting the intrusion of salt water into the aquifer.

- 5. Except for the overdrawn San Dieguito ground water basin, where the present mean seasonal supplemental water requirement is about 800 acre-feet, present water requirements within the watershed are satisfied by the presently developed water supply, including imported Colorado River and San Luis Rey River water. Adequate local and imported water supplies are available to satisfy present water requirements of the City of San Diego.
- 6. Water requirements under probable ultimate conditions of land use will exceed the presently available water supply in all areas of the watershed except San Pasqual ground water basin, and supplemental water requirements in the watershed under these conditions would total about 137,000 acre-feet per season.
- 7. The current rapid growth of the City of San Diego is expected to continue in the future, accompanied by significant increases in water requirements. Increases in the City's mean seasonal water requirements, over and above the 1956-57 water requirements of about 71,000 acre-feet, are estimated to be approximately 59,000 acre-feet in 1970 and in excess of 100,000 acre-feet in 1980.
- 8. Under estimated conditions of ultimate development, only a minor portion of the water requirements in the watershed and in the City of San Diego can be met by local water resources, and, therefore, imported water supplies from the Colorado River Aqueduct, the Feather River and Delta Diversion Projects, and other units of The California Water Plan are essential.
- 9. Purchases of Colorado River water by the City of San Diego and other members of the San Diego County Water Authority presently exceed

their entitlement to this supply. When other member agencies of The Metropolitan Water District of Southern California purchase larger amounts of
Colorado River water, the City's supply from this source will be reduced.

- 10. Conservation of present waste to the ocean from San Dieguito River watershed could be effected, in varying magnitudes and attendant costs, through implementation of the following plans:
 - a. Increased utilization of ground water storage capacity in San Pasqual-Main Lake Hodges Basin.
 - b. Addition of spillway gates on Sutherland Dam.
 - c. Enlargement of San Vicente Reservoir.
 - d. Construction of dams and reservoirs at the Pamo "B",
 San Pasqual, or Super Hodges sites.
- 11. The least costly method of conserving additional water in San Dieguito River watershed on a safe yield basis would be through utilization of \$\frac{1}{41,000}\$ acre-feet of underground storage capacity in San Pasqual-Main Lake Hodges Basin, together with installation of spillway gates on Sutherland Dam. About 3,000 acre-feet of new water per season could be developed immediately in this manner. A new supply of water for the City of San Diego, in the amount of 6,200 acre-feet per season, could be made available under this plan, if the City continues its current program of land acquisition in the basin. This supply of water would include the 3,200 acre-feet per season which has presently been developed and used on lands overlying and adjacent to San Pasqual-Main Lake Hodges Basin.
- 12. The next least costly increment of additional yield, to a maximum of 3,600 acre-feet per season, could be obtained by diversion of flood flows from Sutherland Reservoir to off-stream storage at an enlarged San Vicente Reservoir in the San Diego River watershed.
 - 13. For incremental yields greater than 3,600 acre-feet per season, construction of a dam and reservoir within the San Dieguito River watershed

would be necessary, and such yields would have a lesser over-all and incremental unit cost if they were developed wholely within the watershed rather than in conjunction with an enlarged San Vicente Reservoir.

- l4. The cost of conserving water at a Super Hodges Reservoir is not competitive with that from either a San Pasqual or Pamo "B" reservoir.
- qual sites would be comparable, and such costs at both sites would decrease with increases in reservoir storage capacity considered herein. Water could be conserved at a somewhat lesser unit cost at the San Pasqual site except for the smallest capacities investigated. However, if coordinate operation of surface and ground water storage were initiated at the San Pasqual site subsequent to planned development of the San Pasqual-Main Lake Hodges Basin, water supply facilities existing at that time within the reservoir area would require substantial modification, whereas, no such modification would be necessary with a Pamo "B" Reservoir.
- 16. Construction of a dam and reservoir at the San Pasqual site to the maximum practicable size, and operation of this reservoir in conjunction with spillway gates on Sutherland Dam and with utilization of the ground water storage capacity underlying the reservoir area, would conserve about 60 per cent of present waste to the ocean from San Dieguito River.
- 17. In semiarid San Diego County, where lengthy periods of drought are often experienced, five or ten years might elapse after completion of construction of surface storage facilities before the safe yield could be obtained. For that reason, further development of surface water supplies should be started well in advance of the need for those supplies.

- 18. Yields and costs of the various plans of water development presented in this report are as follows:
- a. San Pasqual-Main Lake Hodges Basin. Capital and annual costs of utilizing the maximum ground water storage capacity of 41,000 acre-feet available in the San Pasqual-Main Lake Hodges Basin are estimated to be \$6,163,700 and \$316,100, respectively, including the cost of lands now owned by the City of San Diego and conveyance facilities. The estimated combined net safe seasonal additional yield to the City of San Diego from this operation would be about 5,800 acre-feet when operated coordinately with Hodges and Sutherland Reservoirs and with the "transfer of spill" operations between Sutherland and existing San Vicente Reservoirs. The average annual unit cost of the developed supply would be about \$54 per acre-foot.

Deducting the value of lands and improvements now owned by the City of San Diego within the project area results in an estimated cost of about \$34 per acre-foot of additional yield.

b. Addition of Spillway Gates on Sutherland Dam. Addition of 13-foot high spillway gates on Sutherland Dam would increase the reservoir capacity by 7,750 acre-feet and the estimated combined net safe yield of Sutherland and Hodges Reservoirs, when operated coordinately, from 9,100 acre-feet to 9,700 acre-feet per season under present conditions of ground water development and with the "transfer of spill" operation between Sutherland and existing San Vicente Reservoirs. The estimated total capital cost of developing the 600 acre-feet of new yield is \$243,500, and the average annual unit cost of new water would be about

\$21 per acre-foot. When 41,000 acre-feet of storage capacity in San Pasqual-Main Lake Hodges Basin are utilized in conjunction with spillway gates on Sutherland Dam, the resulting combined net safe seasonal yield of new water to the City would be 6,200 acre-feet and the average annual additional unit cost to the City of this yield would be \$34 per acre-foot.

- c. Enlarged San Vicente Reservoir. Increasing the height of San Vicente Dam by 42 feet and thereby increasing the storage capacity of the reservoir by 49,400 acre-feet, would provide an incremental seasonal yield of 3,600 acre-feet in excess of that which could be obtained from utilizing 41,000 acre-feet of ground water storage capacity in San Pasqual-Main Lake Hodges Basin in conjunction with spillway gates on Sutherland Dam. This incremental yield could be developed at an additional average annual unit cost to the City of San Diego of \$100 per acre-foot. An enlarged San Vicente Reservoir operated coordinately with the foregoing facilities would provide a combined net safe seasonal yield of water to the City of San Diego of 9,800 acre-feet. The total capital cost is estimated to be \$14,010,000, and the average annual unit cost of water about \$70 per acre-foot. If the value of lands and improvements now owned by the City of San Diego within San Pasqual-Main Lake Hodges Basin is deducted from the project cost, the additional average annual cost to the City would be approximately \$58 per acre-foot of yield.
- d. Pamo "B" Reservoir. Three capacities for Pamo "B"
 Reservoir were considered which would provide incremental seasonal yields
 ranging from 3,600 to 7,600 acre-feet in excess of that which could be
 obtained from utilization of 41,000 acre-feet of ground water storage
 capacity in San Pasqual-Main Lake Hodges Basin, in conjunction with spillway gates on Sutherland Dam, and with the "transfer of spill" operation

between Sutherland and existing San Vicente Reservoirs. These incremental yields could be developed at an additional average annual unit cost to the City of San Diego varying from \$145 to \$93 per acre-foot. Developments at the Pamo "B" site, operated coordinately with the foregoing facilities, would provide a combined net safe seasonal additional yield to the City of San Diego ranging from 9,800 to 13,800 acre-feet. The estimated total capital costs would range from \$17,295,100 to \$21,105,100, including the cost of conveyance facilities. Average annual costs per acre-foot of additional yield would range between about \$87 and \$75 per acre-foot. If the value of lands and improvements already owned by the City in the project area is deducted from the total costs, the additional average annual costs to the City would range between about \$75 and \$66 per acre-foot of additional yield.

e. San Pasqual Reservoir. Three sizes of development at the San Pasqual site, including 37,000 acre-feet of ground water storage capacity within the reservoir area, were considered which would provide incremental seasonal yields ranging from 2,500 to 12,200 acre-feet in excess of that which could be obtained from utilization of \$\pmu1,000\$ acre-feet of ground water storage capacity in San Pasqual-Main Lake Hodges Basin, in conjunction with spillway gates on Sutherland Dam, and with the "transfer of spill" operation between Sutherland and existing San Vicente Reservoirs. These incremental yields could be developed at an additional average annual unit cost to the City of San Diego varying from \$199 to \$76 per acre-foot. The three capacities of San Pasqual Reservoir combined with development of 37,000 acre-feet of ground water storage capacity within the reservoir area, spillway gates on Sutherland Dam, and with "transfer of spill" operation between Sutherland and existing San Vicente Reservoirs would provide a combined net safe seasonal additional yield to the City of San

Diego ranging from 8,700 to 18,400 acre-feet. The estimated total capital costs would range from \$15,968,000 to \$23,394,300, including the cost of conveyance facilities. Average annual costs per acre-foot of additional yield would range between about \$91 and \$67 per acre-foot. If the value of lands and improvements already owned by the City in the project area is deducted from the total costs, the additional average annual costs to the City would range between about \$81 and \$62 per acre-foot of additional yield.

f. <u>Super Hodges Reservoir</u>. Three capacities for Super Hodges Reservoir were considered, which, combined with spillway gates on Sutherland Dam, and "transfer of spill" operation of Sutherland and existing San Vicente Reservoirs, would provide a combined net safe seasonal additional yield to the City of San Diego ranging from 4,600 to 13,500 acre-feet. The estimated total capital costs would range from \$20,285,800 to \$37,049,100, including the cost of conveyance facilities. Average annual costs per acre-foot of additional yield would range between \$215 and \$135 per acre-foot. The cost of developing 41,000 acre-feet of ground water storage capacity within the reservoir area was not estimated as the new yield would not alter the cost-yield relationship for the Super Hodges project to such a degree as to render it competitive with alternative developments in the San Dieguito River watershed.

If the value of lands now owned by the City within the project area and the cost of non-City modification of U. S. Highway No. 395 are deducted from the project cost, the additional average annual costs to the City would range between \$160 and \$101 per acre-foot of additional yield.

19. Substantial flood control benefits would result from construction of the largest considered size of Pamo "B", San Pasqual, or

Super Hodges Dam by reduction of peak flows by reservoir surcharge storage only. On this basis, it is estimated that average annual benefits would be \$93,500 for Pamo "B" Reservoir with a capacity of 163,400 acrefeet, \$102,300 for San Pasqual Reservoir with a capacity of 335,000 acre-feet, and \$150,000 for Super Hodges Reservoir with a capacity of 365,000 acre-feet. No appreciable flood control benefits in the San Dieguito River watershed would result from conservation effected by an enlarged San Vicente Reservoir.

- 20. Considerably greater benefits would accrue if credit were taken for reduction of peak flows in reservoirs from both surcharge storage and storage space occurring 50 per cent of the time on April 1. On this basis, average annual benefits creditable to the largest Pamo "B", San Pasqual, and Super Hodges Reservoirs would be \$119,400, \$222,000, and \$246,500, respectively.
- 21. The present worth of the average annual benefits for the 365,000 acre-foot capacity Super Hodges Reservoir evaluated herein, considering, first, surcharge storage only and, secondly, surcharge storage combined with available storage space occurring 50 per cent of the time on April 1, is estimated to be \$3,517,000 and \$5,779,000, respectively.

Recommendations

1. Plans for further development of the water resources of the San Dieguito River watershed be based upon conclusions of this investigation.

- 2. Federal participation in the interest of flood control be sought in planning and implementation of water conservation development in the watershed.
- 3. The program of collection, compilation, and evaluation of basic hydrologic data throughout the San Dieguito River watershed be continued to provide a basis for accomplishing maximum practicable conservation of its water resources.
- 4. Continuing effort be made to obtain adequate imported water supplies through the Feather River and Delta Diversion Projects and other units of The California Water Plan, to augment the limited local water resources of San Diego County and available importations from the Colorado River.





LEGEND



SAN DIEGUITO RIVER WATERSHED BOUNDARY



HYDROLOGIC UNIT BOUNDARY



SUBUNIT BOUNDARY

NOTE: ANNEXATION DATA FURNISHED BY CITY OF SAN DIEGO OR SAN DIEGO COUNTY WATER AUTHORITY.

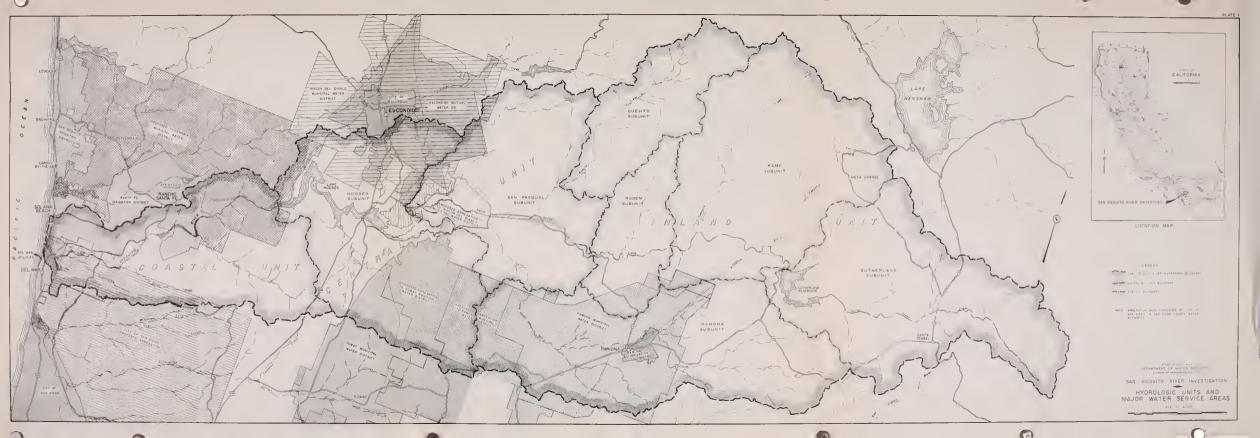


SAN DIEGUITO RIVER INVESTIGATION

HYDROLOGIC UNITS AND MAJOR WATER SERVICE AREAS

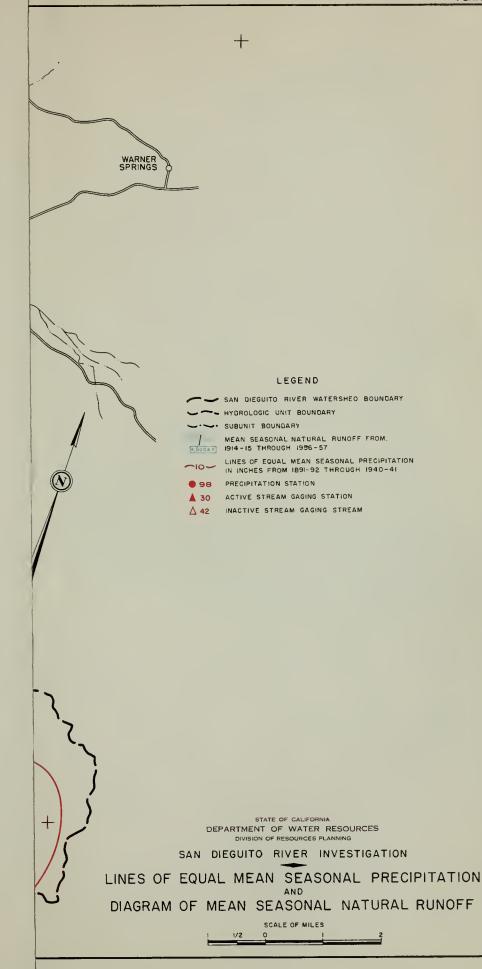
SCALE OF MILES

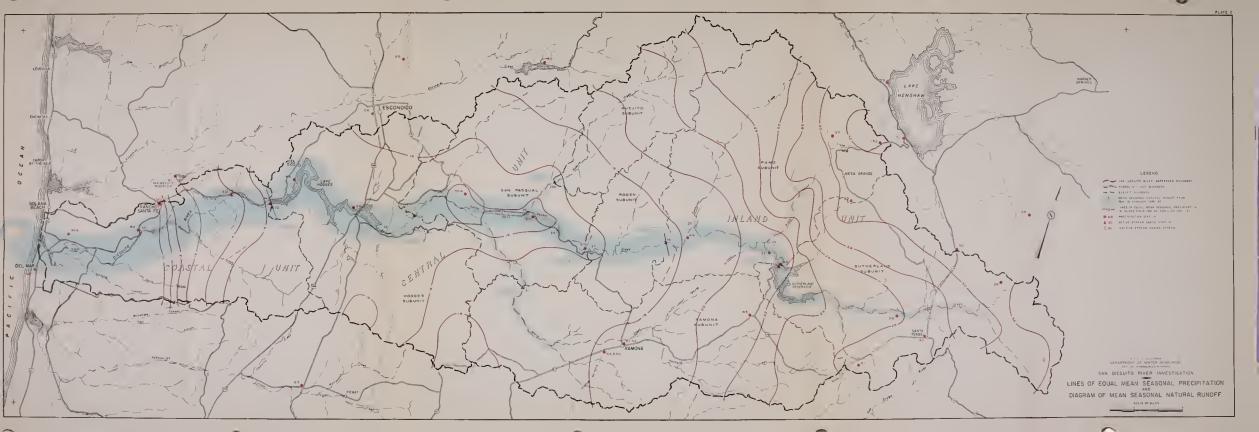


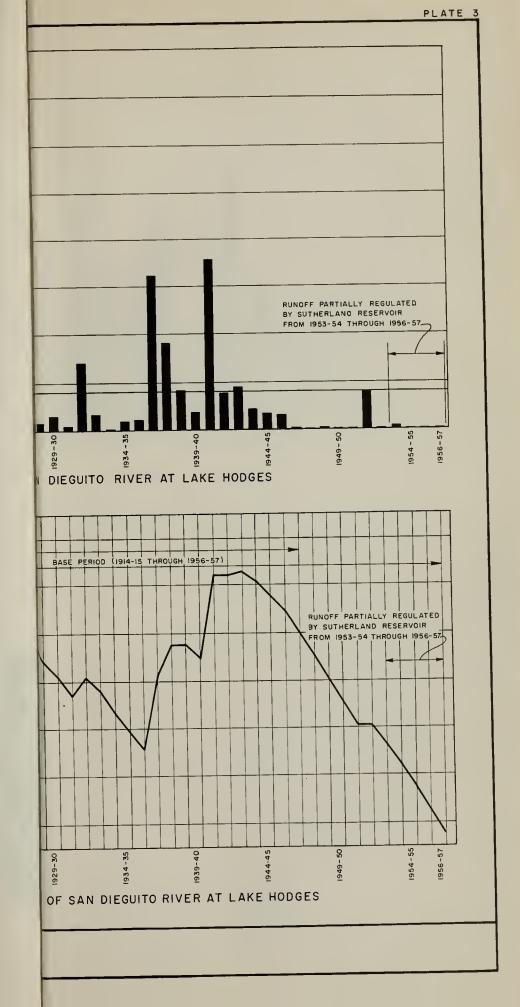


WARNER SPRINGS LEGEND SAN DIEGUITO RIVER WATERSHED BOUNDARY - HYDROLOGIC UNIT BOUNDARY . SUBUNIT BOUNDARY MEAN SEASONAL NATURAL RUNOFF FROM. LINES OF EQUAL MEAN SEASONAL PRECIPITATION IN INCHES FROM 1891-92 THROUGH 1940-41 PRECIPITATION STATION ▲ 30 ACTIVE STREAM GAGING STATION △ 42 INACTIVE STREAM GAGING STREAM STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES DIVISION OF RESOURCES PLANNING SAN DIEGUITO RIVER INVESTIGATION LINES OF EQUAL MEAN SEASONAL PRECIPITATION DIAGRAM OF MEAN SEASONAL NATURAL RUNOFF SCALE OF MILES

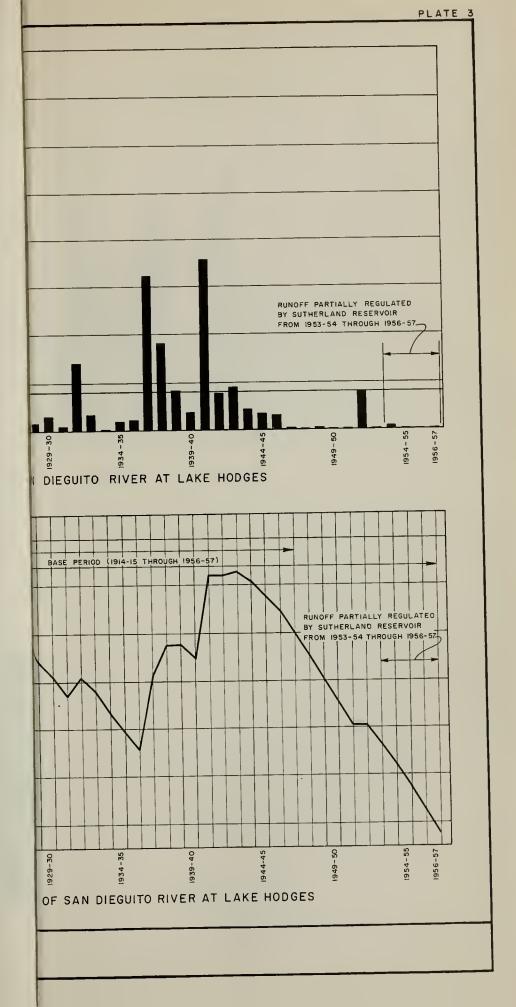


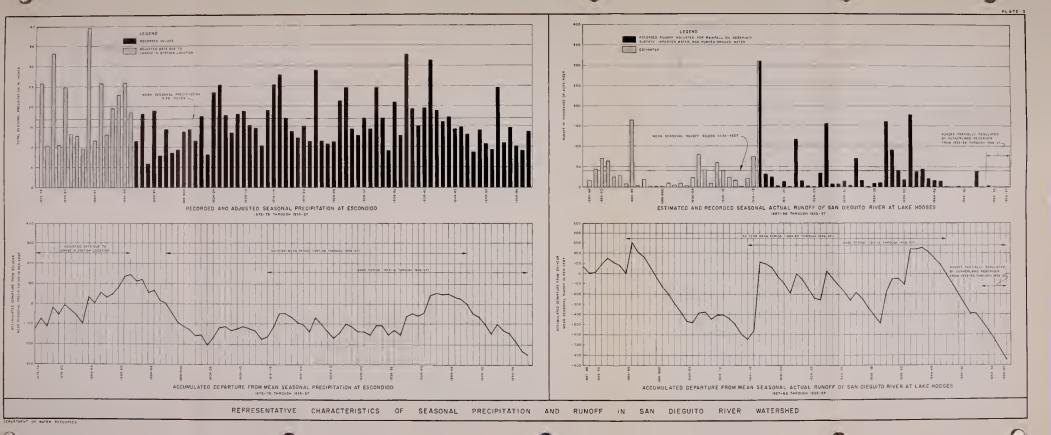


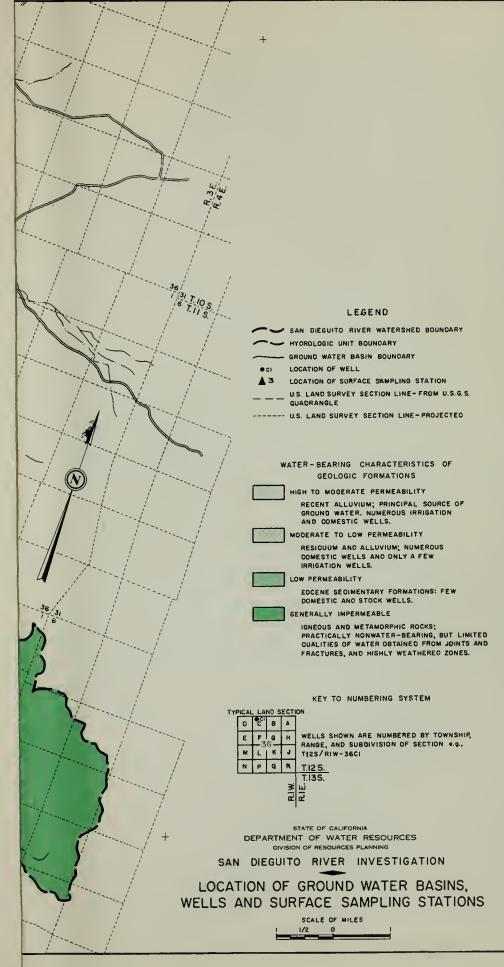




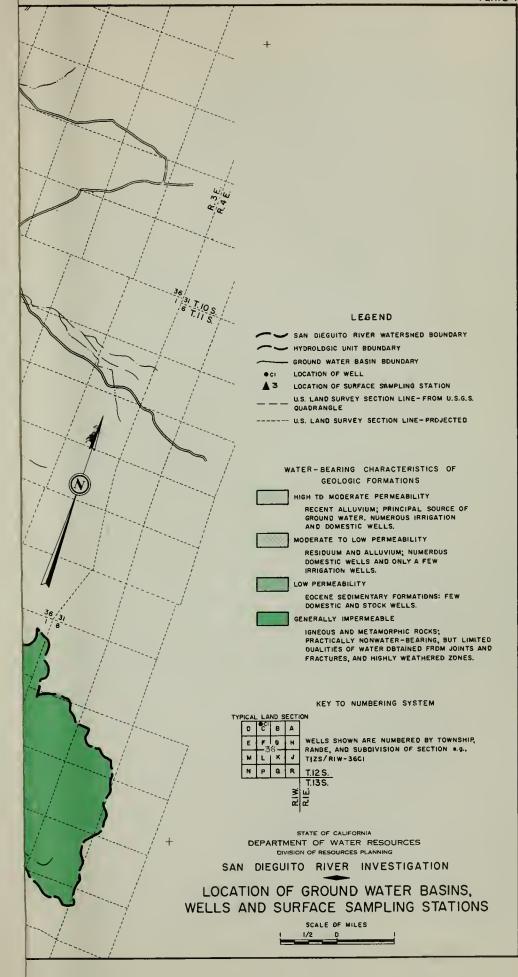


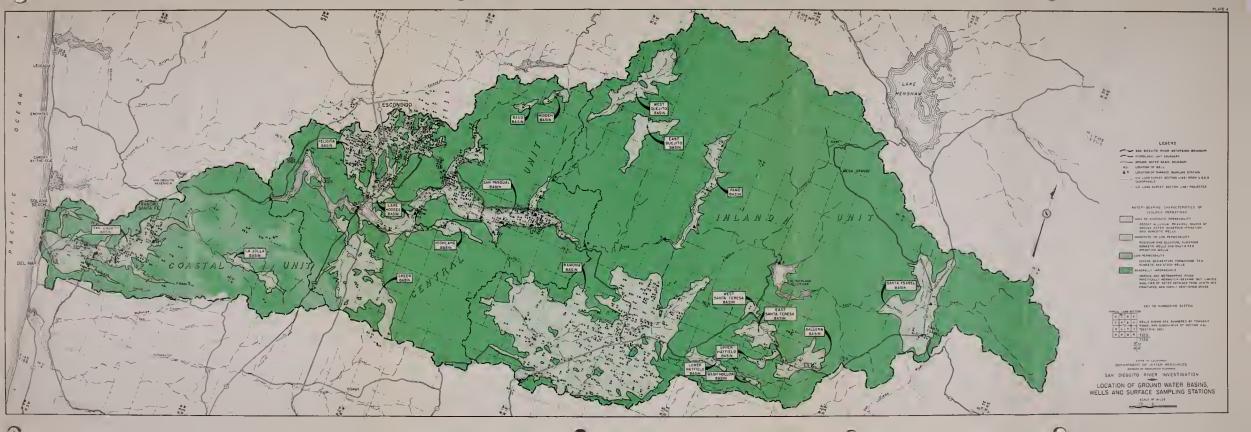


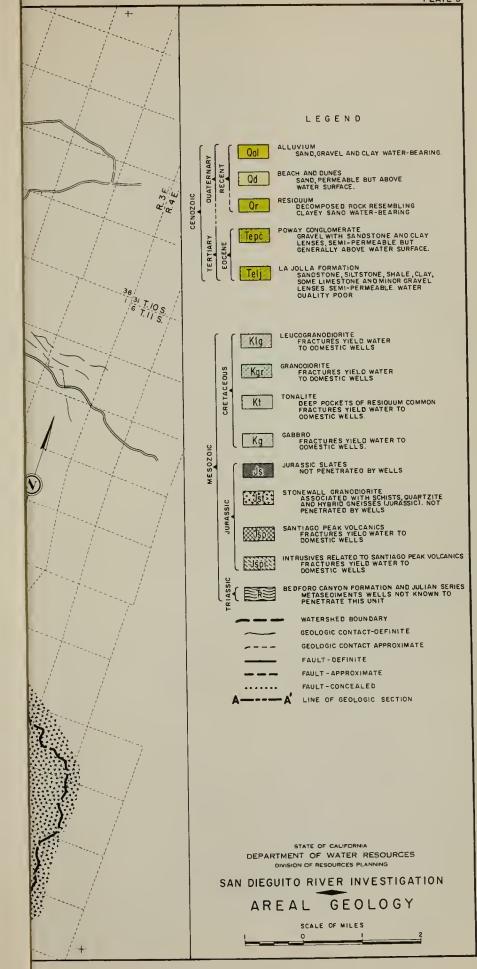




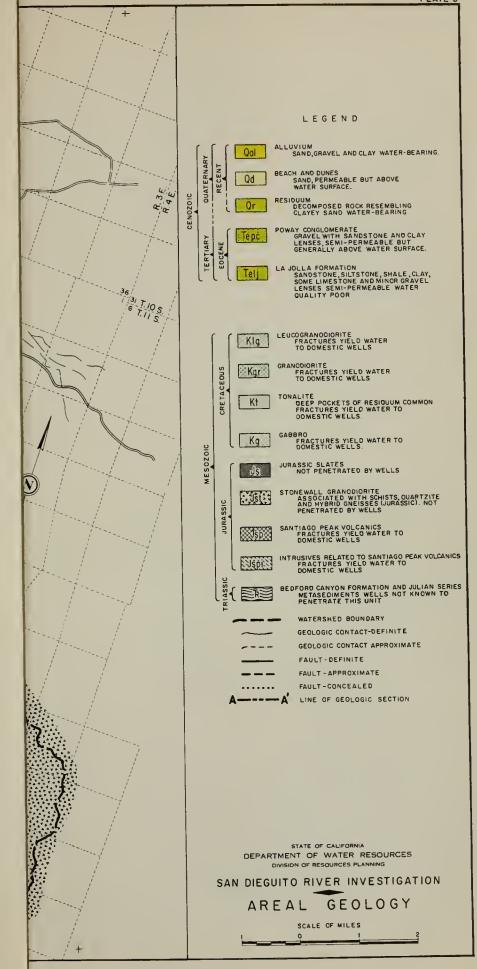


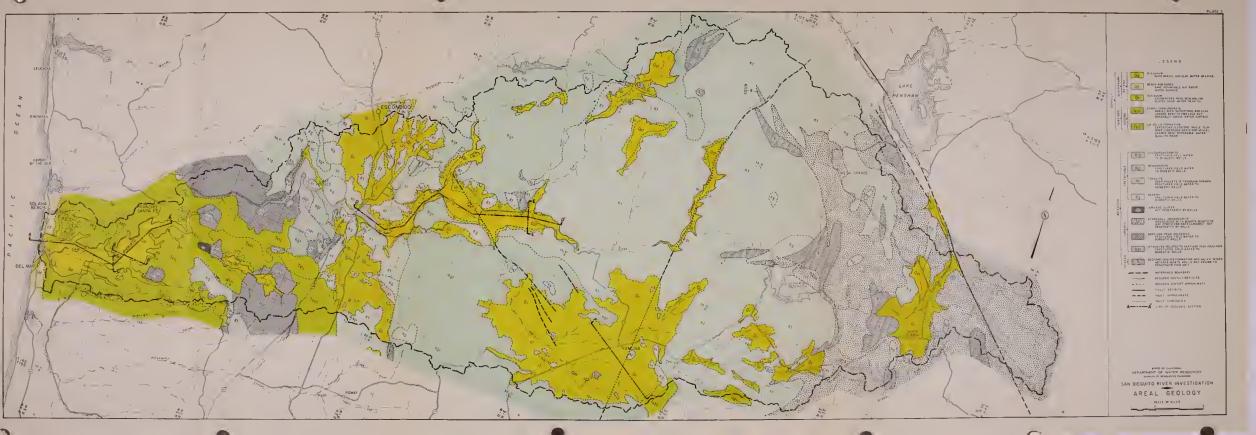










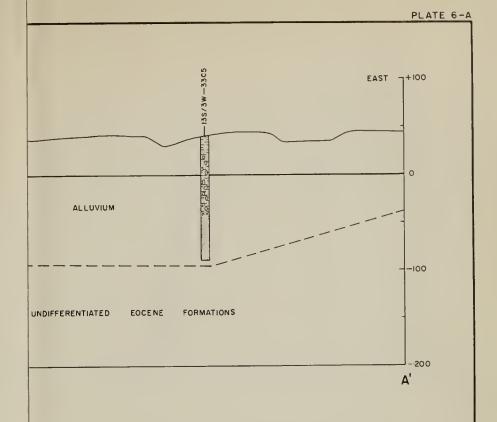


SAN DIEGUITO RIVER INVESTIGATION

GEOLOGIC SECTIONS A-A', B-B', AND C-C'

SCALE OF FEET 1000 0 1000 2000 3000

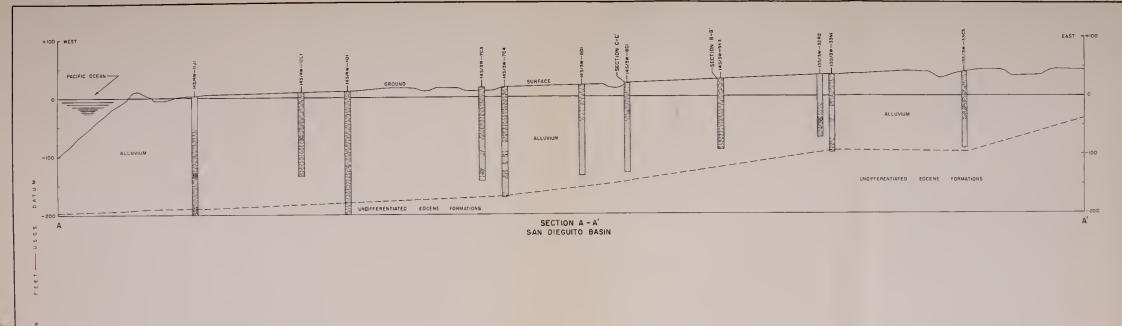


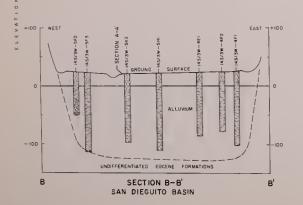


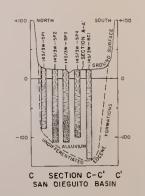
SAN DIEGUITO RIVER INVESTIGATION

GEOLOGIC SECTIONS A-A', B-B', AND C-C'

SCALE OF FEET 1000 0 1000 2000 3000







SANOY CLAY, OR SILT
SANO
GRAVEL

NOTE LOCATION OF SECTIONS SHOWN ON PLATE 5

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESDURCES
DIVISION OF RESDURCES PLANNING

SAN DIEGUITO RIVER INVESTIGATION

GEOLOGIC SECTIONS A-A', B-B', AND C-C'

SCALE OF FEET 2000 5000

SAN DIEGUITO RIVER INVESTIGATION

GEOLOGIC SECTIONS D-D', E-E', AND F-F'

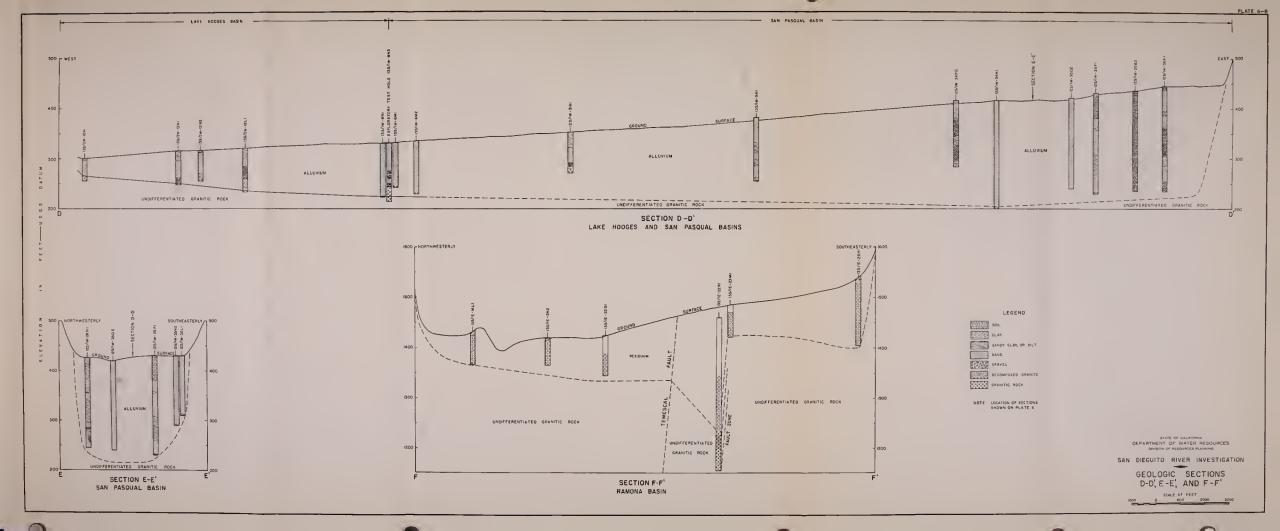
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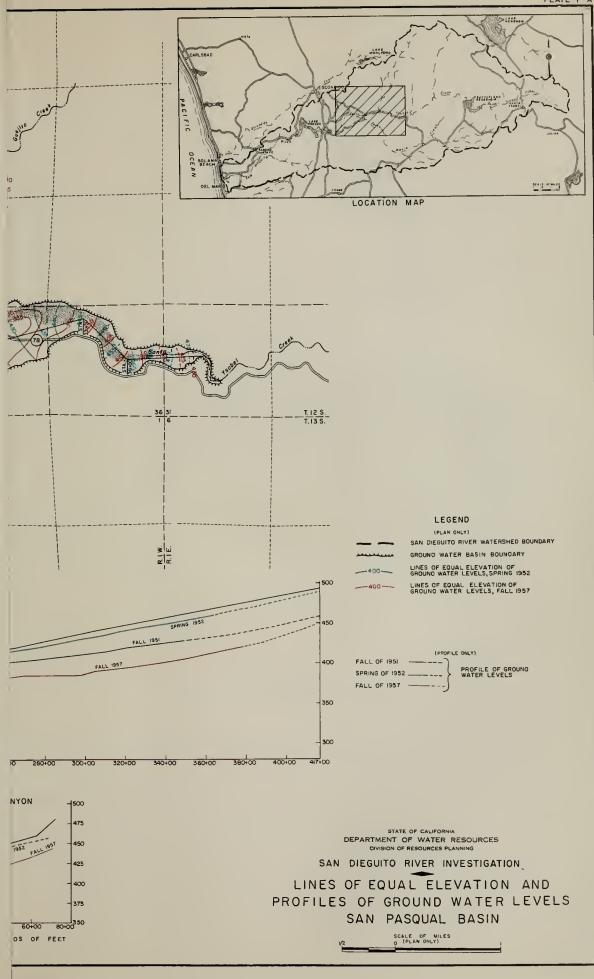


SAN DIEGUITO RIVER INVESTIGATION

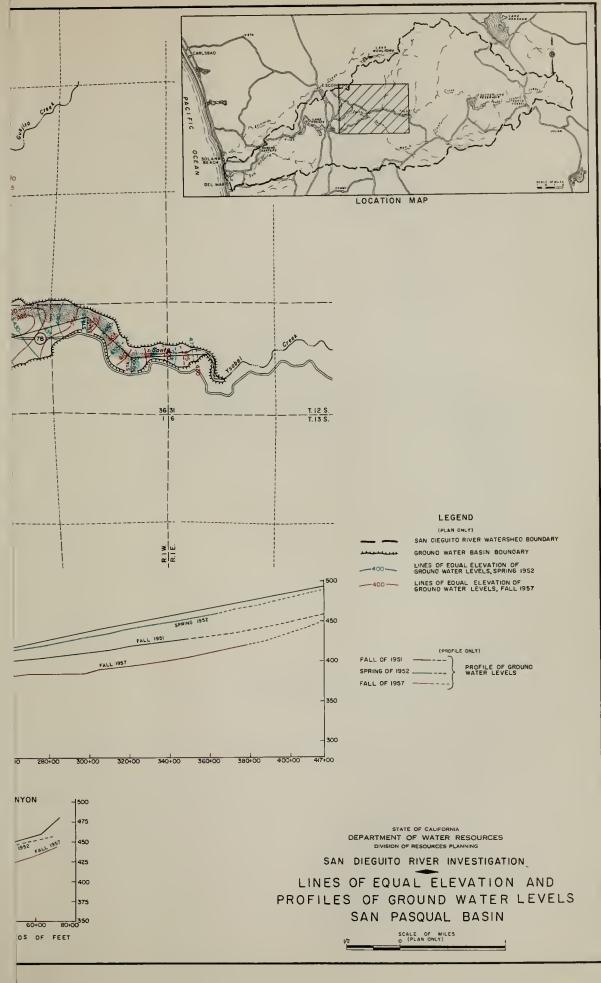
GEOLOGIC SECTIONS D-D', E-E', AND F-F'

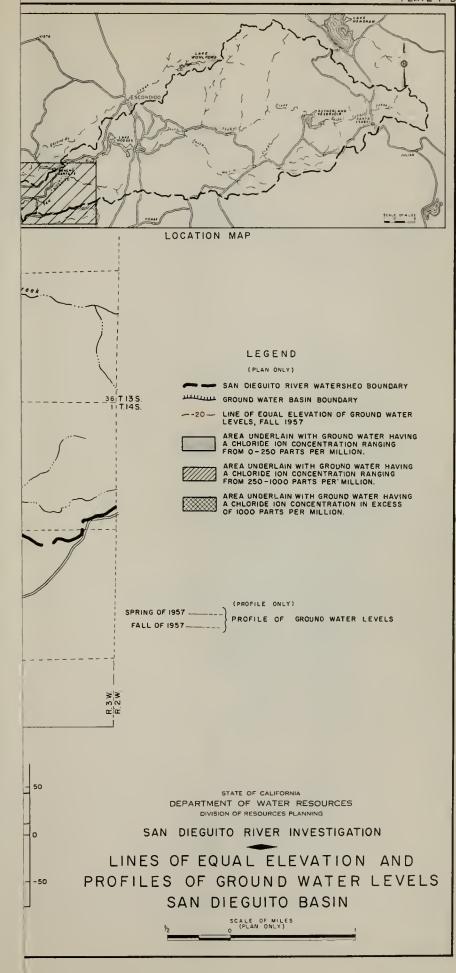
SCALE OF FEET 1000 0 1000 2000 3000



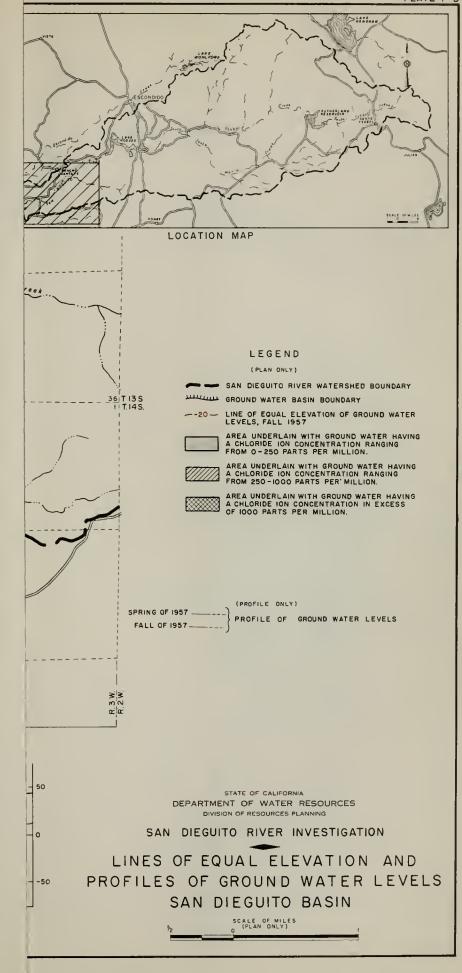


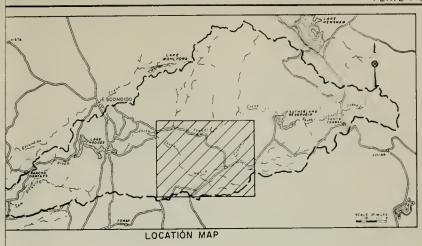












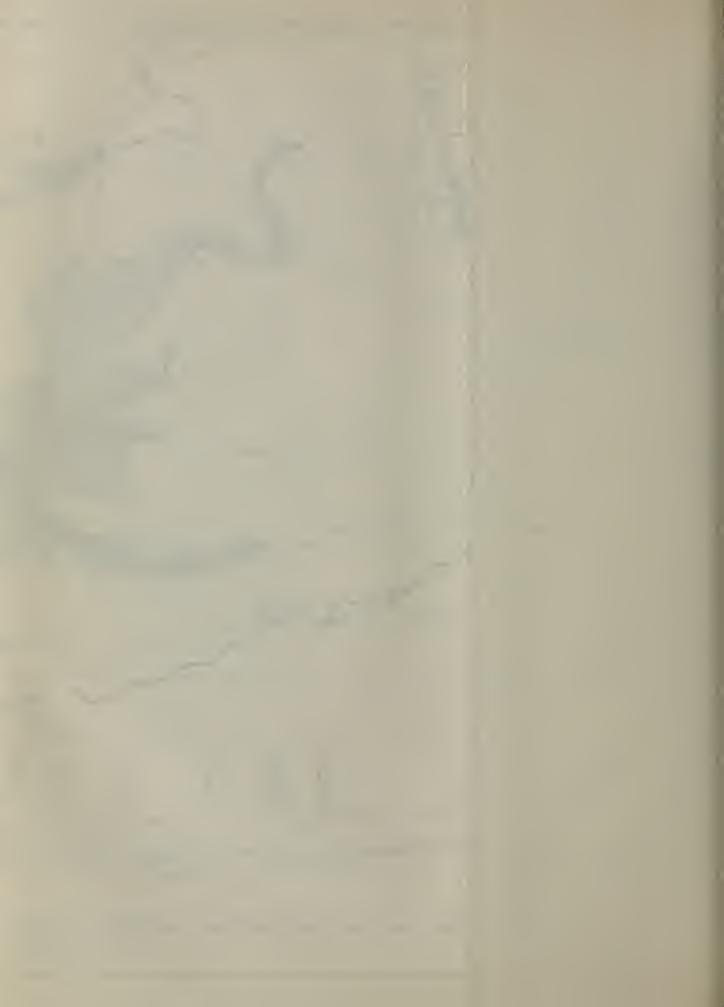
GROUND WATER BASIN BOUNDARY

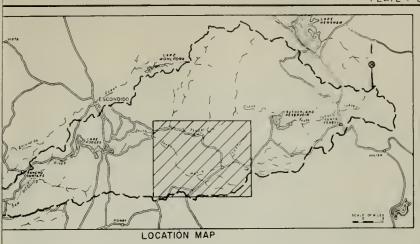
LINES OF EQUAL ELEVATION OF
GROUND WATER LEVELS, FALL 1957

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

SAN DIEGUITO RIVER INVESTIGATION

LINES OF EQUAL ELEVATION OF GROUND WATER LEVELS RAMONA BASIN





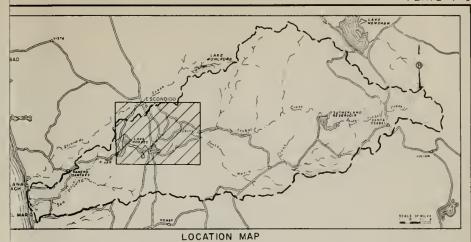
GROUND WATER BASIN BOUNDARY

LINES OF EQUAL ELEVATION OF
GROUND WATER LEVELS, FALL 1957

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

SAN DIEGUITO RIVER INVESTIGATION

LINES OF EQUAL ELEVATION OF GROUND WATER LEVELS RAMONA BASIN



SAN DIEGUITO RIVER WATERSHED BOUNDARY

GROUND WATER BASIN BOUNDARY

LINES OF EQUAL ELEVATION OF
GROUND WATER LEVELS, FALL 1957

STATE OF CALIFORNIA

DEPARTMENT OF WATER RESOURCES

DIVISION OF RESOURCES PLANNING

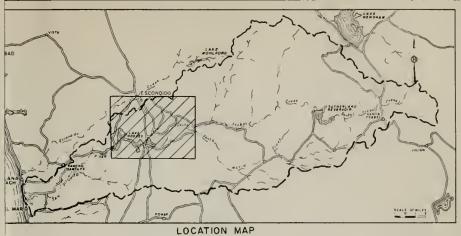
SAN DIEGUITO RIVER INVESTIGATION

LINES OF EQUAL ELEVATION OF GROUND WATER LEVELS FELICITA AND LAKE HODGES BASINS

SCALE OF MILES

1/2 0



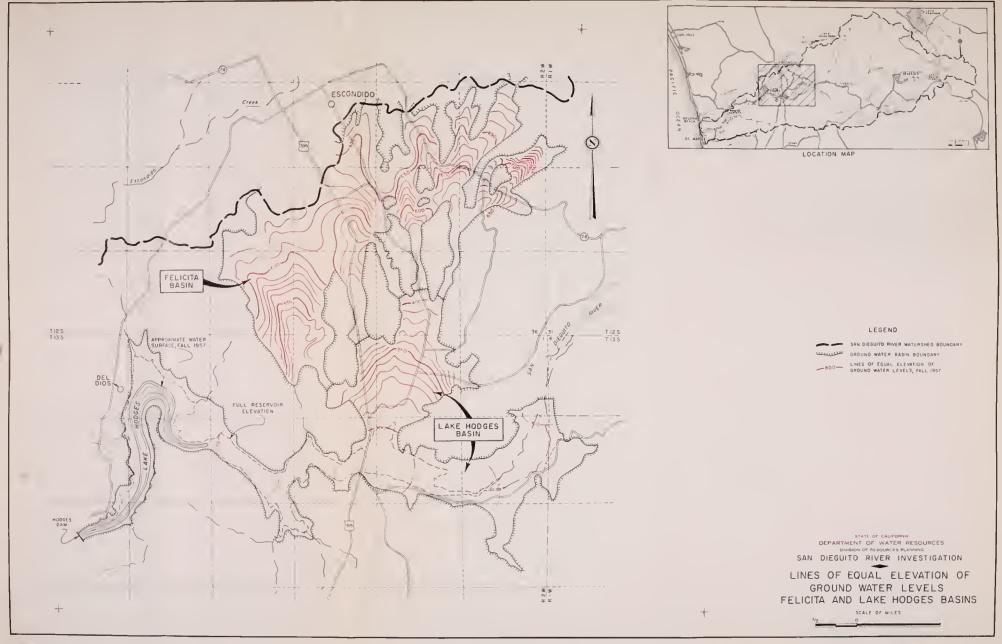


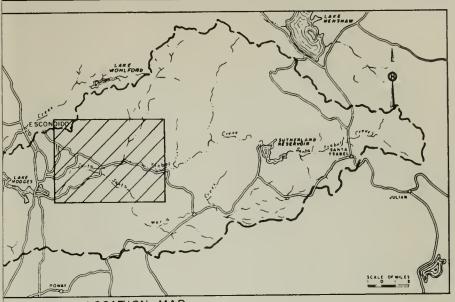
SAN DIEGUITO RIVER WATERSHED BOUNDARY GROUNO WATER BASIN BOUNDARY LINES OF EQUAL ELEVATION OF GROUND WATER LEVELS, FALL 1957

STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES DIVISION OF RESOURCES PLANNING

SAN DIEGUITO RIVER INVESTIGATION

LINES OF EQUAL ELEVATION OF GROUND WATER LEVELS FELICITA AND LAKE HODGES BASINS





LOCATION MAP

LEGEND



WATERSHED BOUNDARY
GROUND WATER BASIN BOUNDARY
LINES OF EQUAL NET CHANGE IN GROUND
WATER LEVEL ELEVATION

r. 12 S. r. 13 S.

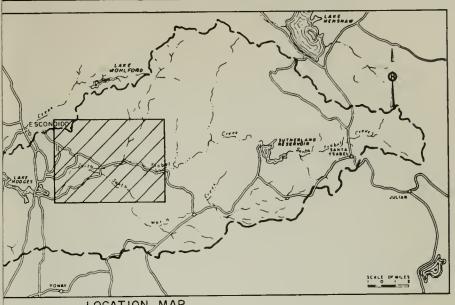
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

LINES OF EQUAL NET CHANGE
IN

GROUND WATER LEVEL ELEVATION

SPRING 1952 TO FALL 1957
SAN PASQUAL BASIN





LOCATION MAP

LEGEND



WATERSHED BOUNDARY GROUND WATER BASIN BOUNDARY LINES OF EQUAL NET CHANGE IN GROUND WATER LEVEL ELEVATION

T. 12 S. 7. 13 S.

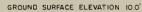
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

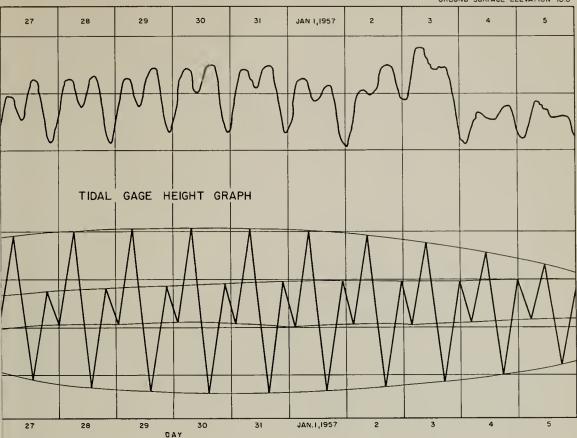
SAN DIEGUITO RIVER INVESTIGATION LINES OF EQUAL NET CHANGE IN GROUND WATER LEVEL ELEVATION SPRING 1952 TO FALL 1957 SAN PASQUAL BASIN

SAN DIEGUITO BASIN

F WATER LEVELS IN WELL 145/4W- IQI AND TIDAL FLUCTUATIONS







NOTE: LOCATION OF WELLS SHOWN ON PLATE 4

FLUCTUATION OF WATER LEVELS AT SELECTED WELLS

"F" INDICATES PERIOD DURING WHICH WELL FLOWED

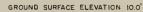
"PR" INDICATES PUMP RUNNING WHEN OBSERVER MEASURED DEPTH TO WATER

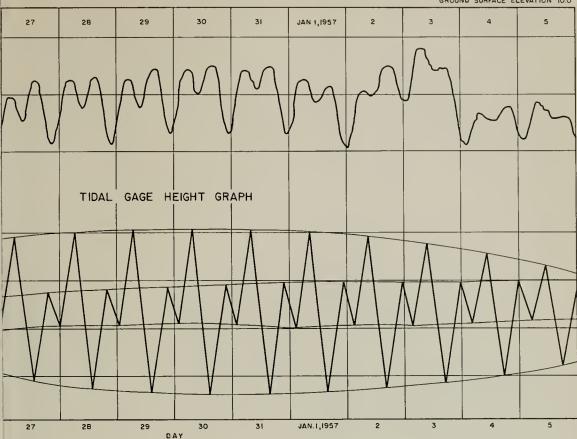


SAN DIEGUITO BASIN

F WATER LEVELS IN WELL 145/4W - IQI AND TIDAL FLUCTUATIONS





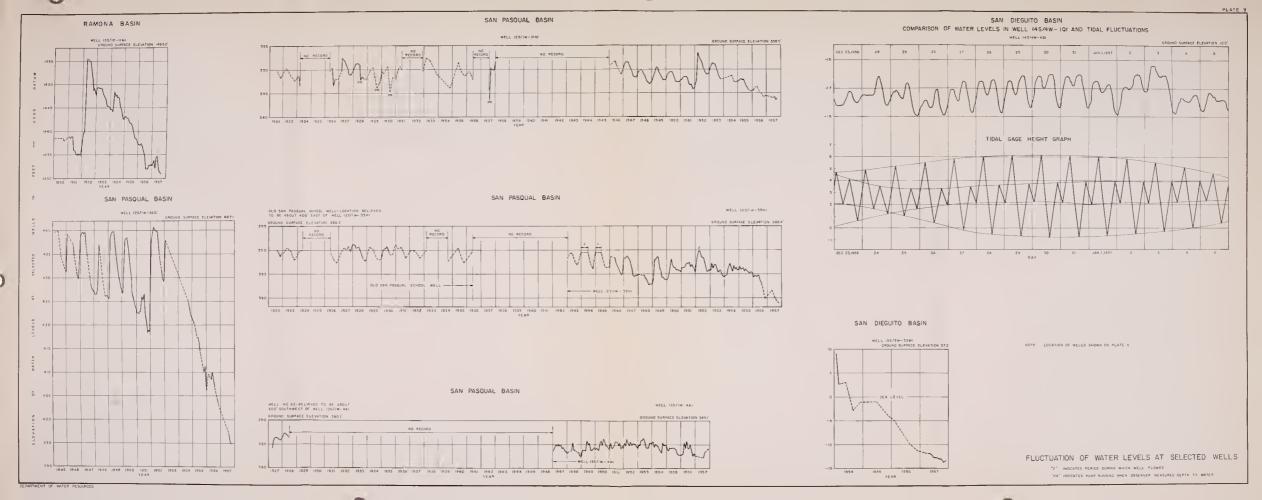


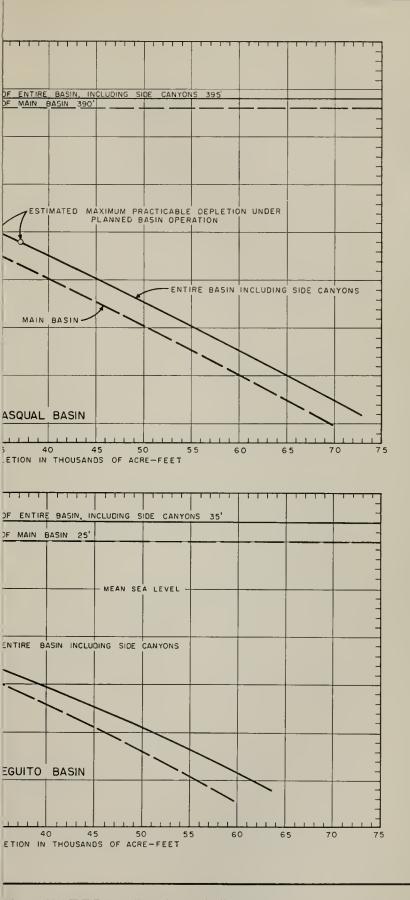
NOTE: LOCATION OF WELLS SHOWN ON PLATE 4

FLUCTUATION OF WATER LEVELS AT SELECTED WELLS

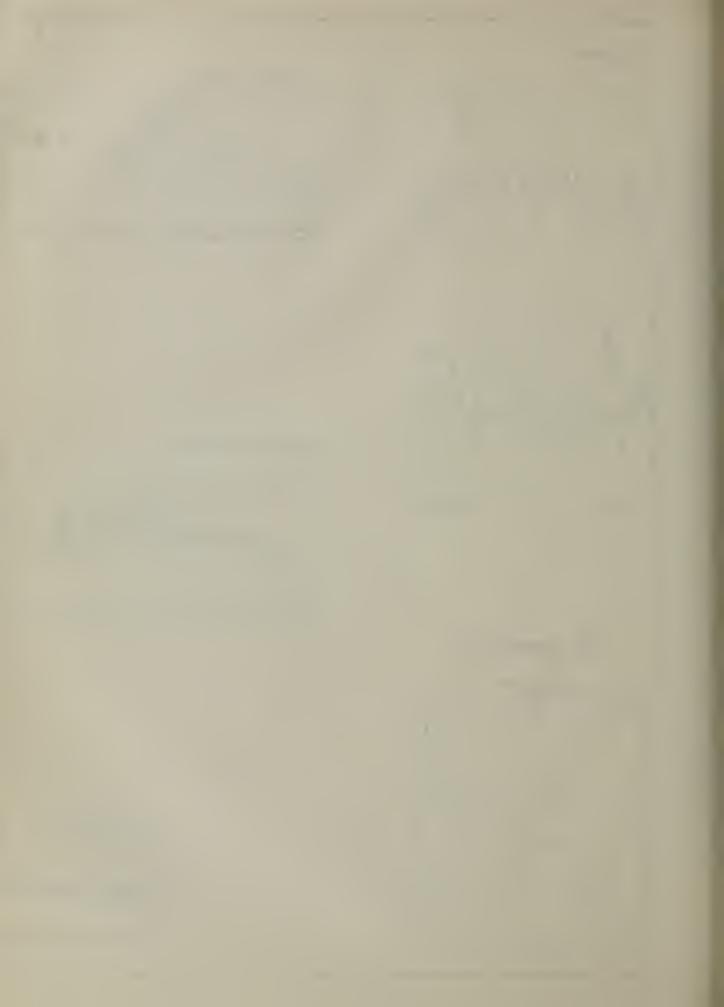
"F" INDICATES PERIOD DURING WHICH WELL FLOWED

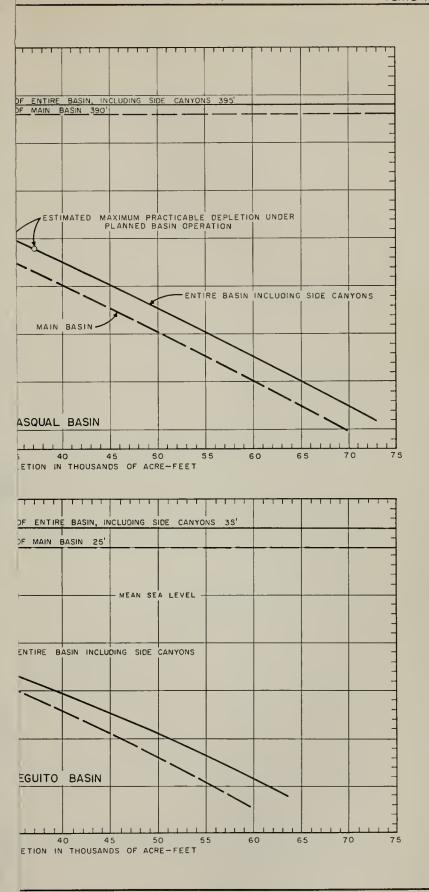
"PR" INDICATES PUMP RUNNING WHEN OBSERVER MEASURED DEPTH TO WATER



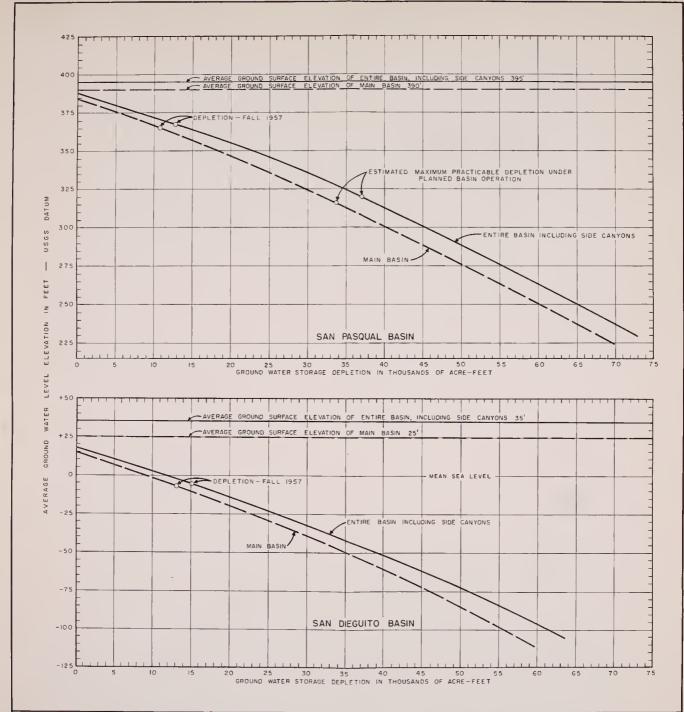


AGE WATER LEVEL ELEVATION STORAGE DEPLETION

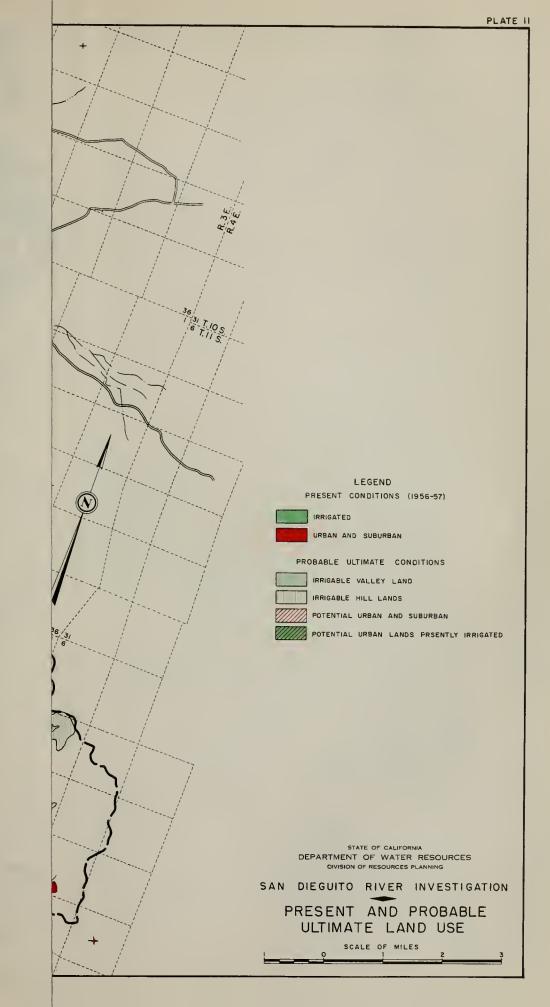




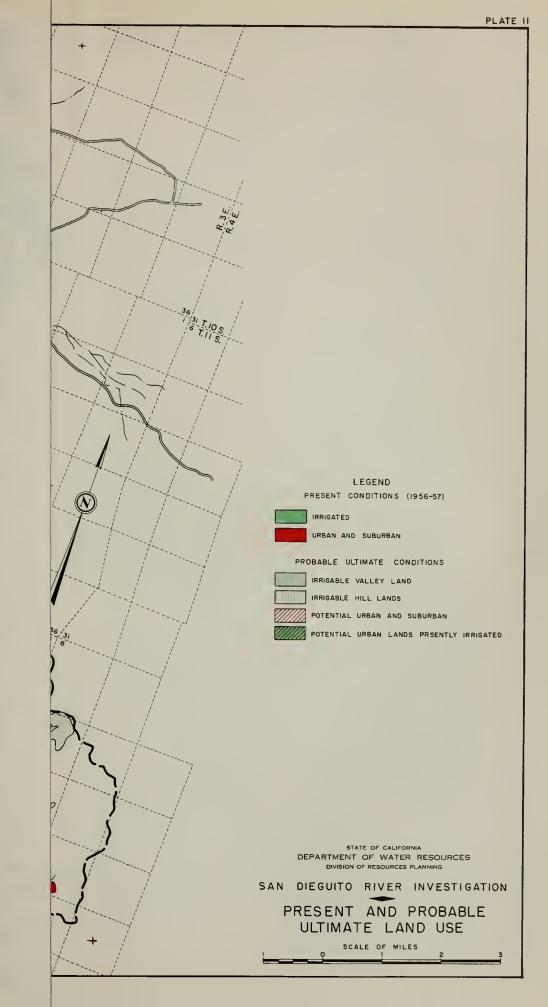
AGE WATER LEVEL ELEVATION STORAGE DEPLETION

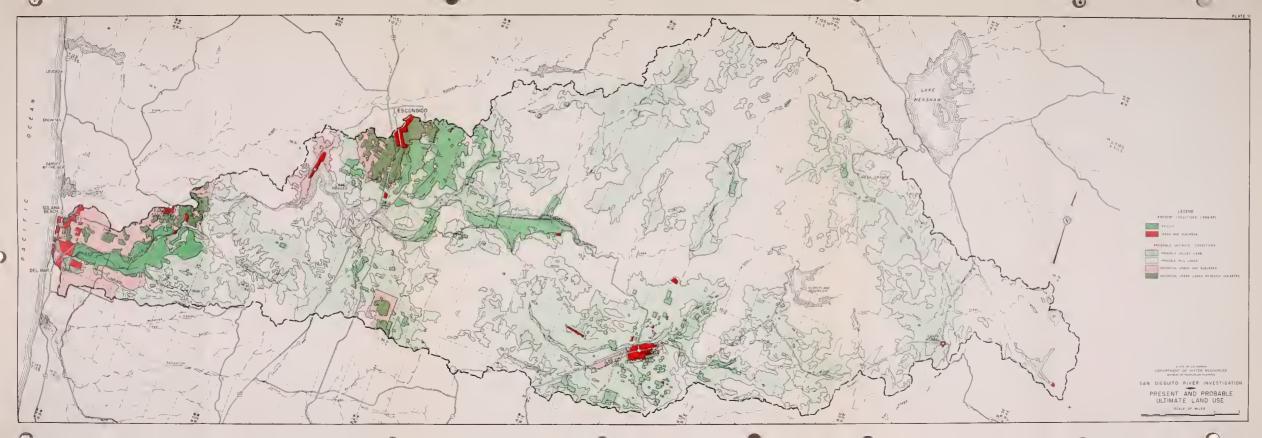


RELATIONSHIP BETWEEN AVERAGE WATER LEVEL ELEVATION
AND GROUND WATER STORAGE DEPLETION

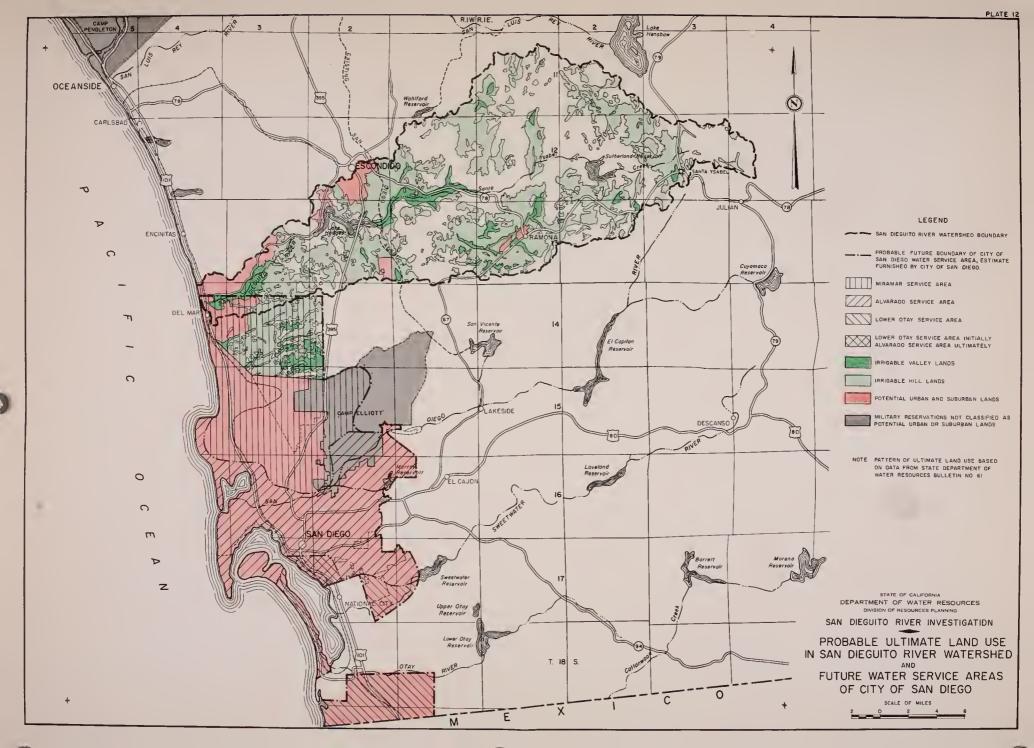


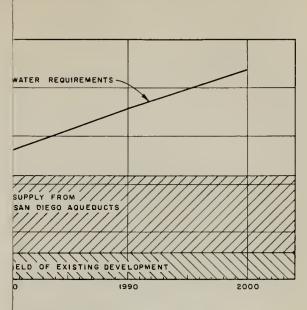




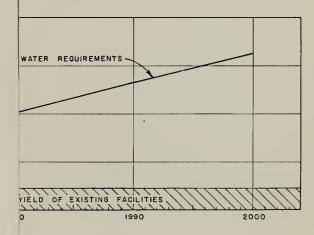




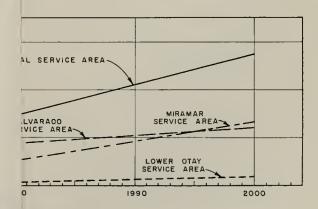




LE FUTURE WATER REQUIREMENTS OASTAL SAN DIEGO COUNTY

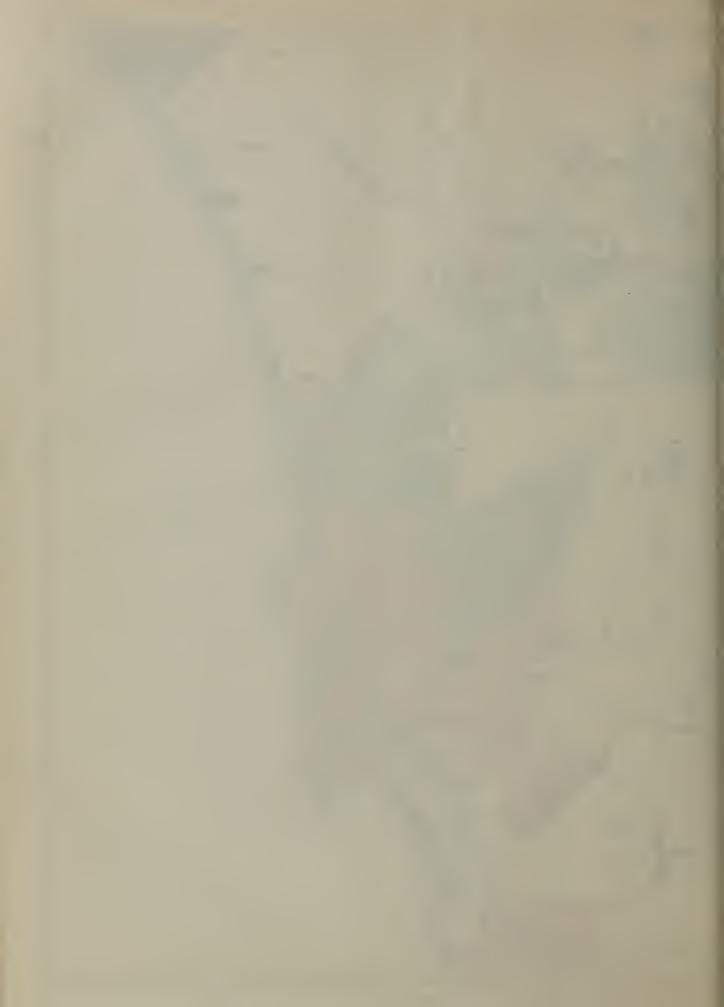


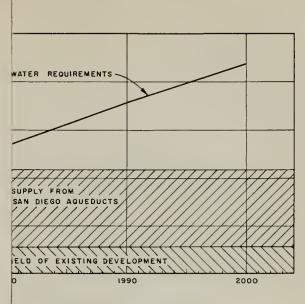
LE FUTURE WATER REQUIREMENTS R SERVICE AREA OF CITY OF SAN DIEGO



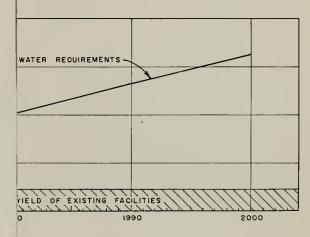
REQUIREMENTS
REAS OF CITY OF SAN DIEGO

REQUIREMENTS AND LOCAL AFFECTING CITY OF SAN DIEGO

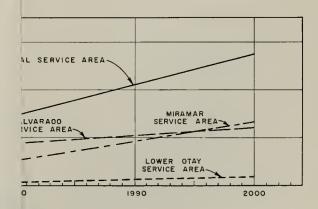




LE FUTURE WATER REQUIREMENTS OASTAL SAN DIEGO COUNTY

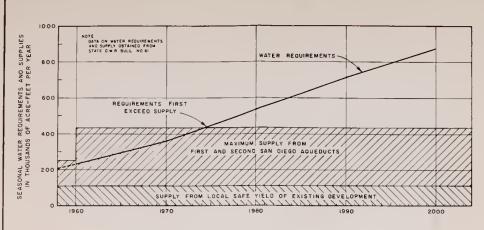


LE FUTURE WATER REQUIREMENTS
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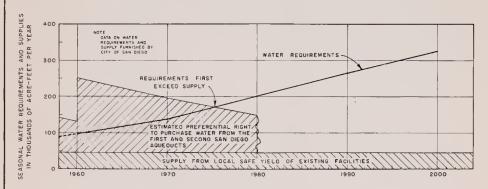


REQUIREMENTS REAS OF CITY OF SAN DIEGO

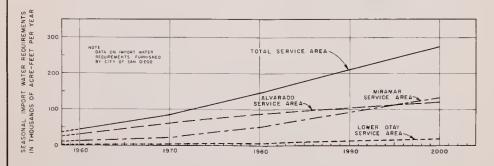
REQUIREMENTS AND LOCAL AFFECTING CITY OF SAN DIEGO



RELATIONSHIP BETWEEN PROBABLE FUTURE WATER REQUIREMENTS
AND WATER SUPPLY OF COASTAL SAN DIEGO COUNTY



RELATIONSHIP BETWEEN PROBABLE FUTURE WATER REQUIREMENTS
AND WATER SUPPLY OF FUTURE WATER SERVICE AREA OF CITY OF SAN DIEGO



IMPORT WATER REQUIREMENTS
OF FUTURE WATER SERVICE AREAS OF CITY OF SAN DIEGO

RELATIONSHIP BETWEEN WATER REQUIREMENTS AND LOCAL AND IMPORTED WATER SUPPLIES AFFECTING CITY OF SAN DIEGO



LEGEND

- SAN DIEGUITO RIVER WATERSHED BOUNDARY

PROBABLE FUTURE BOUNDARY OF CITY OF SAN DIEGO WATER SERVICE AREA AS FURNISHED BY CITY OF SAN DIEGO.

MAJOR EXISTING WATER SUPPLY FACILITIES OF CITY OF SAN DIEGO.

POTENTIAL FACILITIES FOR DEVELOPMENT OF WATER RESOURCES IN SAN DIEGUITO RIVER WATERSHED

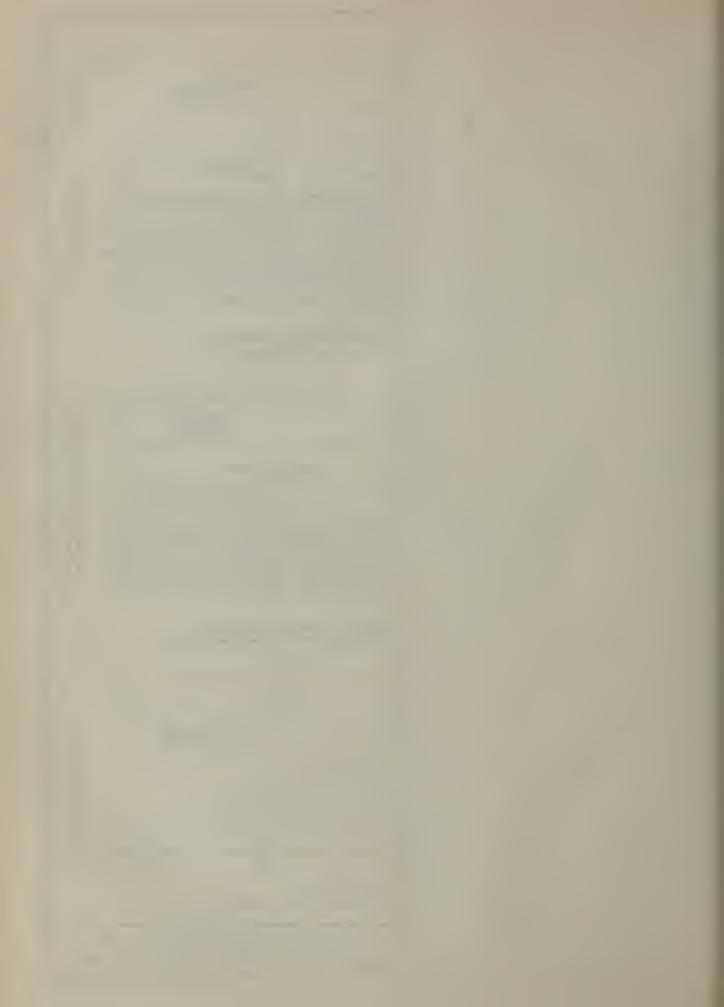
PROSPECTIVE FACILITIES OF THE CALIFORNIA WATER PLAN AFFECTING SAN DIEGUITO WATERSHED.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

SAN DIEGUITO RIVER INVESTIGATION

EXISTING AND POTENTIAL ALTERNATIVE FACILITIES
FOR WATER SUPPLY DEVELOPMENT
IN SAN DIEGUITO RIVER WATERSHED
AND MAJOR RELATED WORKS

SCALE OF MILES





LEGEND

- SAN DIEGUITO RIVER WATERSHED BOUNDARY

PROBABLE FUTURE BOUNDARY OF CITY OF SAN DIEGO WATER SERVICE AREA AS FURNISHED BY CITY OF SAN DIEGO.

MAJOR EXISTING WATER SUPPLY FACILITIES OF CITY OF SAN DIEGO.

 POTENTIAL FACILITIES FOR DEVELOPMENT OF WATER RESOURCES IN SAN DIEGUITO RIVER WATERSHED.

PROSPECTIVE FACILITIES OF THE CALIFORNIA WATER PLAN AFFECTING SAN DIEGUITO WATERSHED.

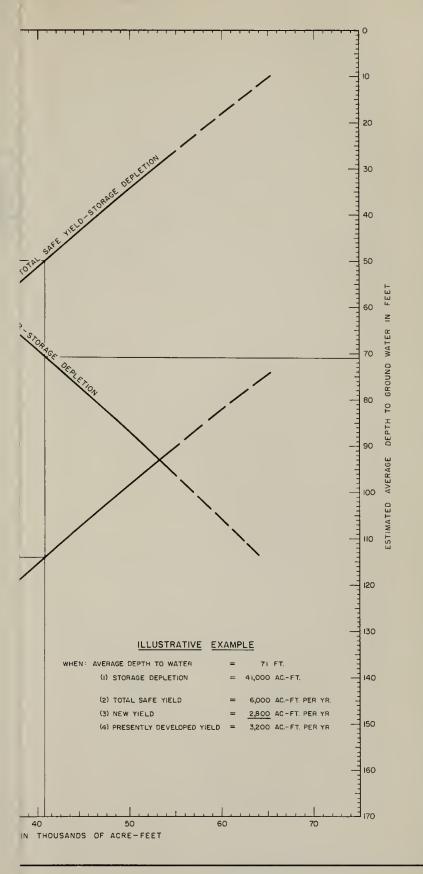
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

SAN DIEGUITO RIVER INVESTIGATION

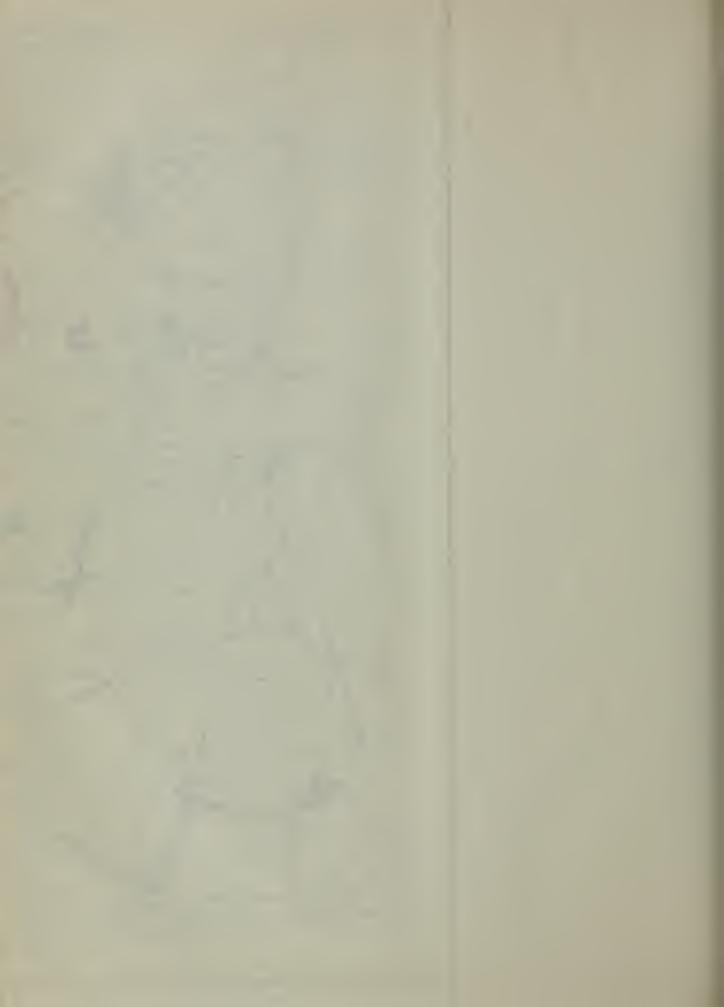
EXISTING AND POTENTIAL ALTERNATIVE FACILITIES
FOR WATER SUPPLY DEVELOPMENT
IN SAN DIEGUITO RIVER WATERSHED
AND MAJOR RELATED WORKS

SCALE OF MILES
5 10

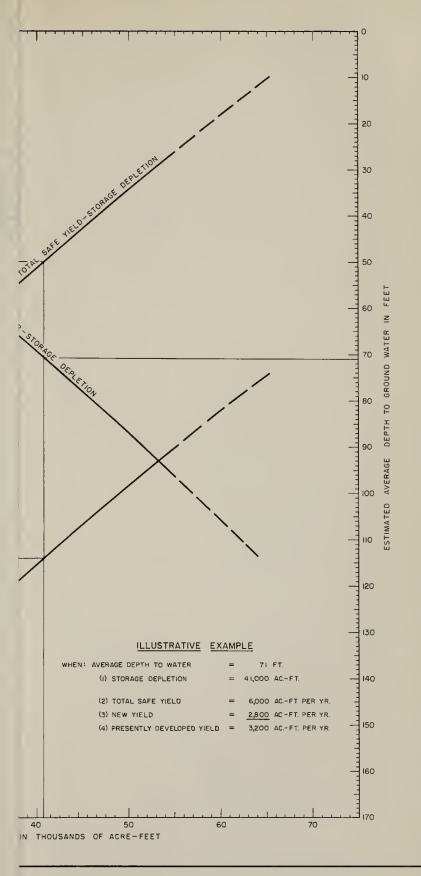




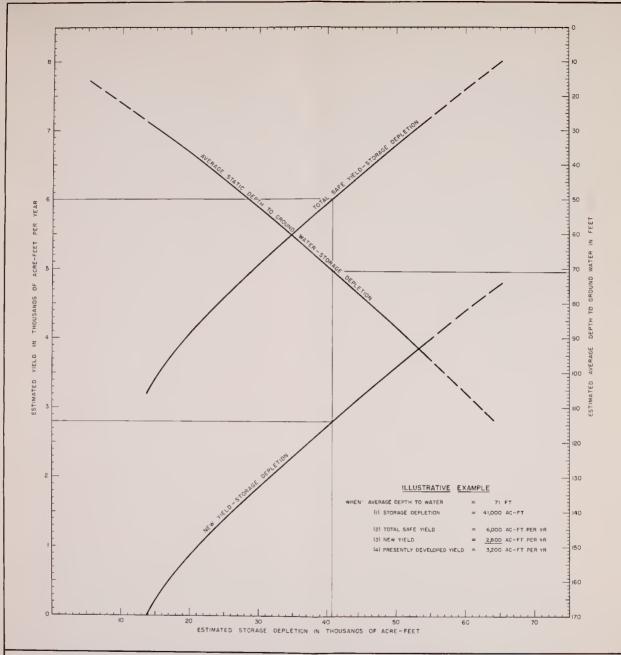
BETWEEN
), AND AVERAGE DEPTH TO GROUND WATER
V LAKE HODGES BASINS
6-57 ADJUSTED FOR PRESENT CONDITIONS



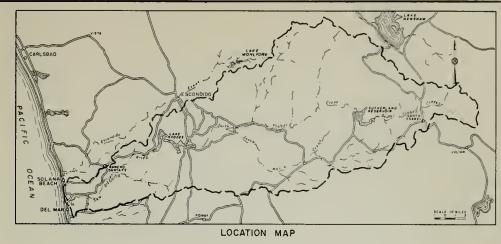




BETWEEN
), AND AVERAGE DEPTH TO GROUND WATER
V LAKE HODGES BASINS
6-57 ADJUSTED FOR PRESENT CONDITIONS



RELATIONSHIP BETWEEN
GROUND WATER STORAGE DEPLETION, YIELD, AND AVERAGE DEPTH TO GROUND WATER
IN SAN PASQUAL AND MAIN LAKE HODGES BASINS
FOR THE PERIOD FROM 1914-15 THROUGH 1956-57 ADJUSTED FOR PRESENT CONDITIONS





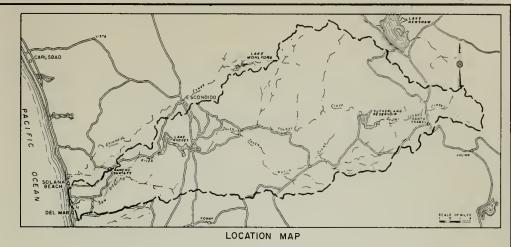
T.12 S. T.13 S.

FOR PLANNED OPERATION OF SAN PASQUAL-MAIN LAKE HODGES BASIN

GROUND WATER STORAGE DEPLETION OF 41,000 ACRE-FEET SAFE SEASONAL YIELD OF 6,000 ACRE-FEET

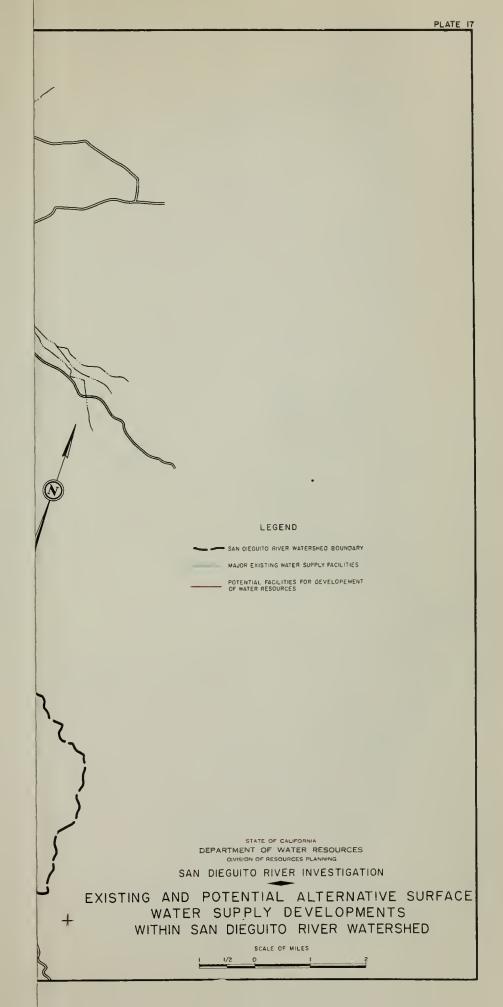
SCALE OF MILES

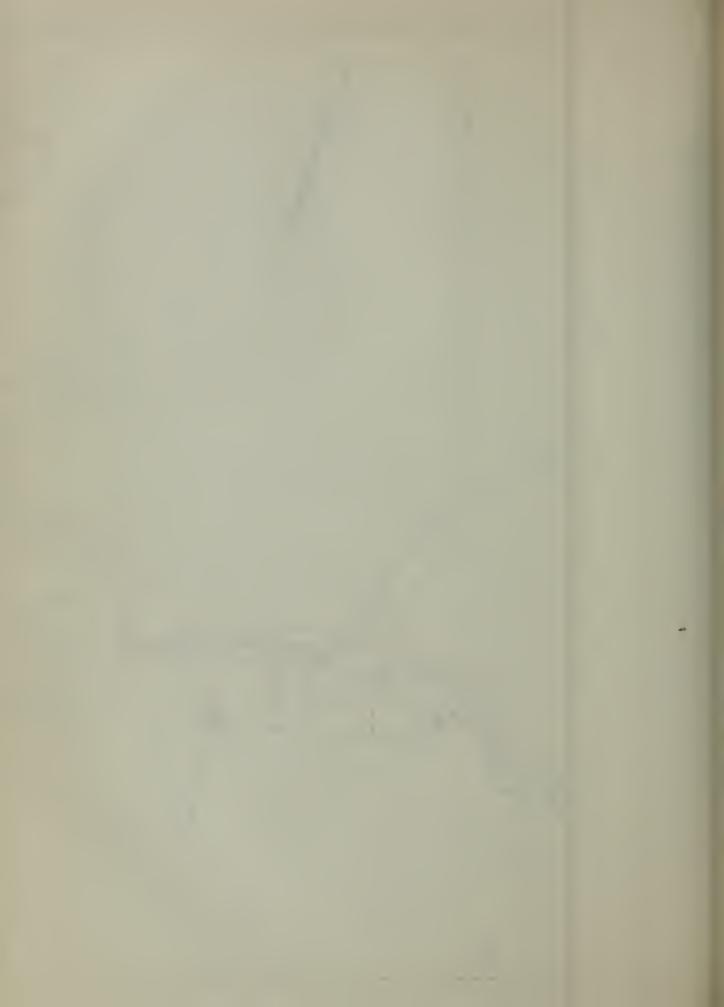


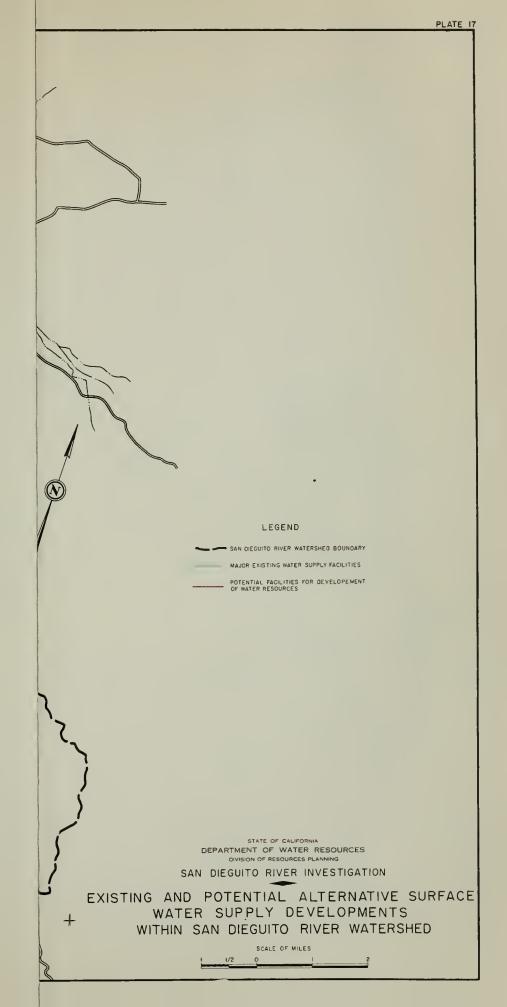


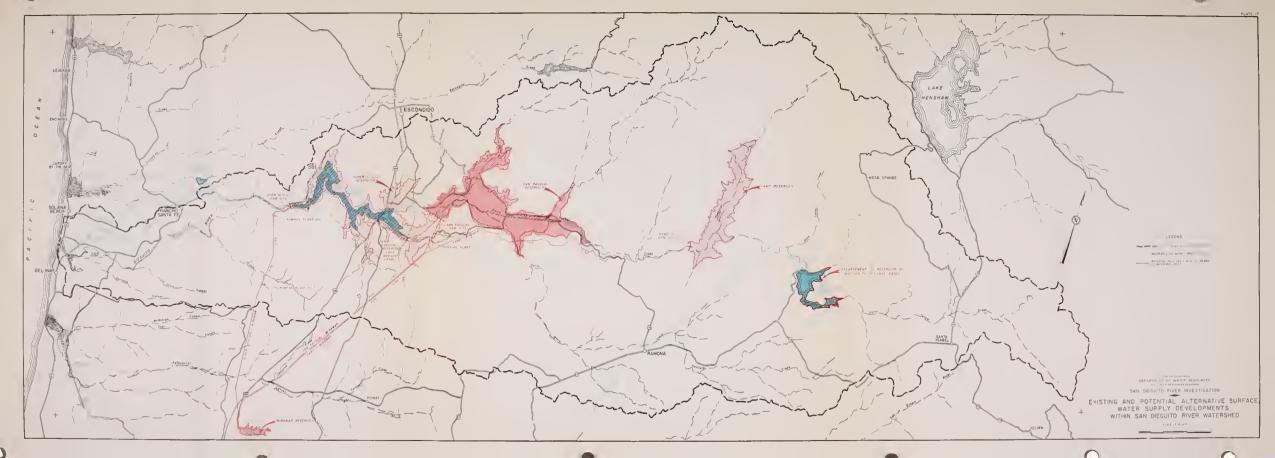


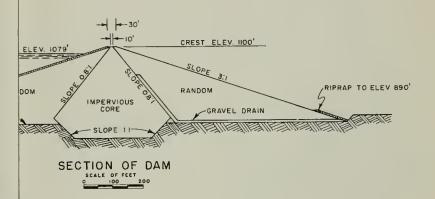












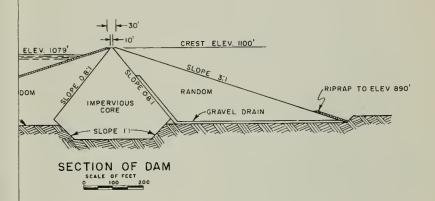
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

SAN DIEGUITO RIVER INVESTIGATION

PAMO DAM AT SITE "B" ON SANTA YSABEL CREEK

RESERVOIR STORAGE CAPACITY OF 163,400 ACRE FEET



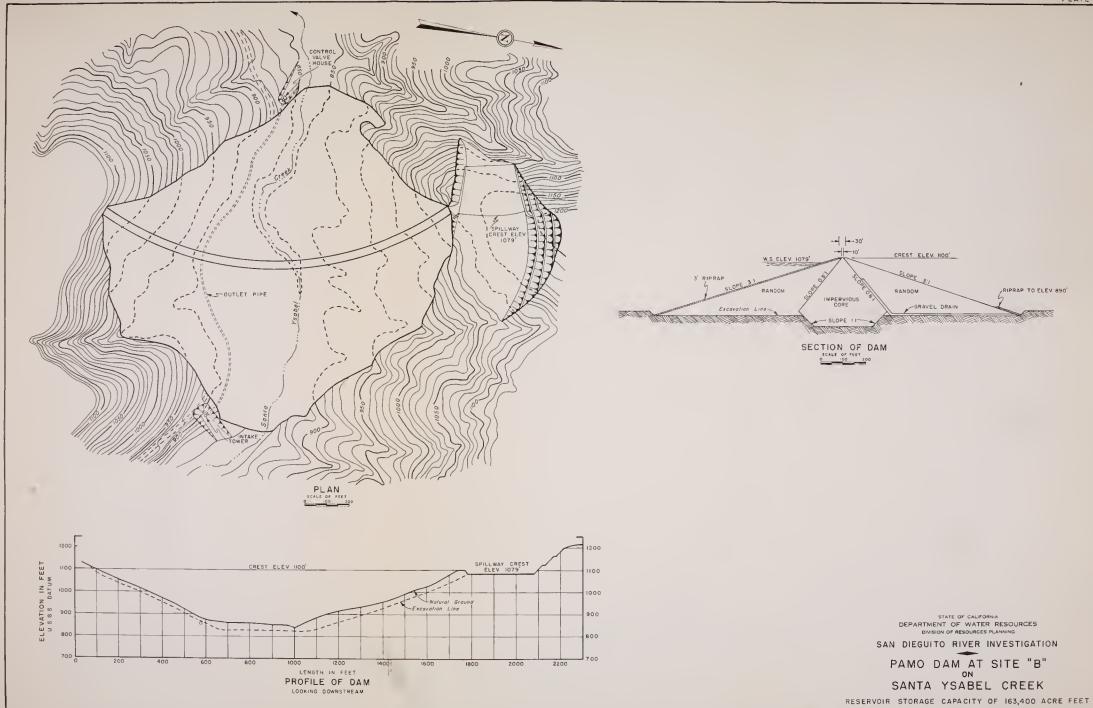


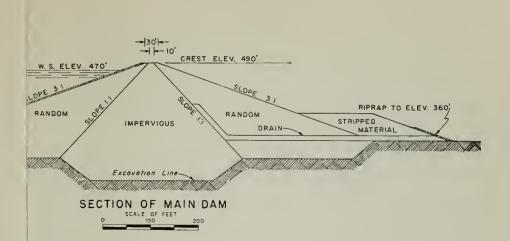
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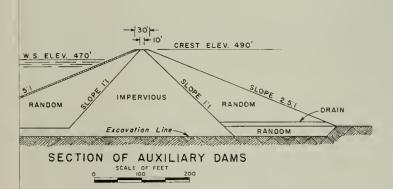
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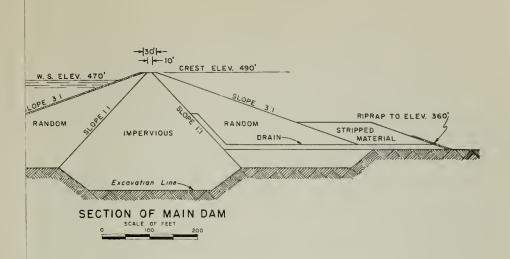


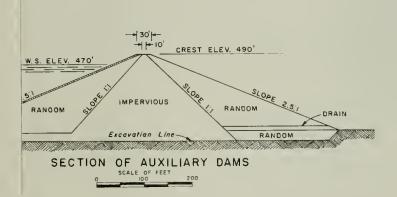
SAN DIEGUITO RIVER INVESTIGATION

SAN PASQUAL DAM
ON
SAN DIEGUITO RIVER

RESERVOIR STORAGE CAPACITY OF 335,000 ACRE-FEET



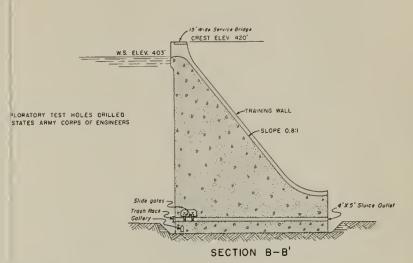


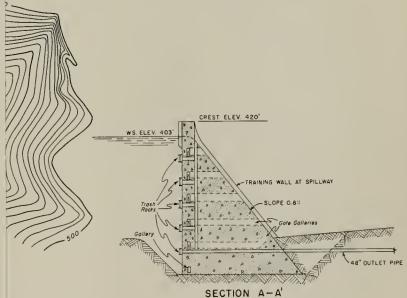


SAN DIEGUITO RIVER INVESTIGATION

SAN PASQUAL DAM SAN DIEGUITO RIVER

RESERVOIR STORAGE CAPACITY OF 335,000 ACRE-FEET



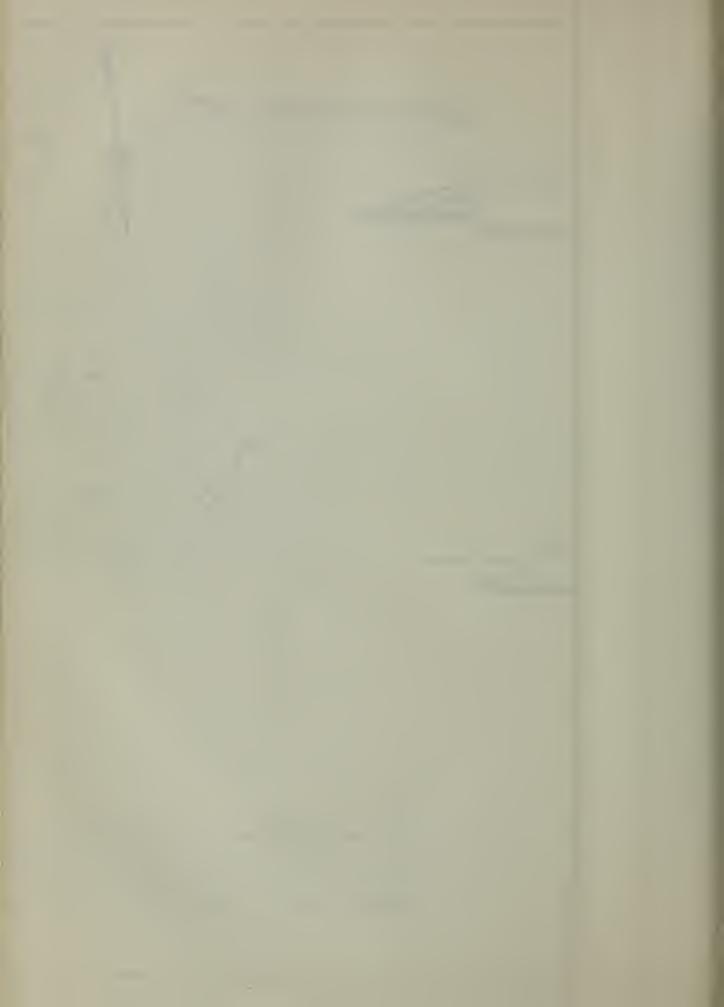


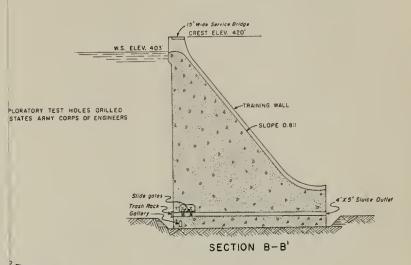
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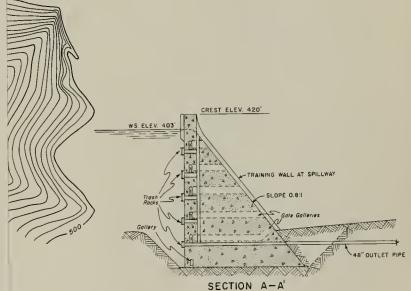
SUPER HODGES DAM
SAN DIEGUITO RIVER

RESERVOIR STORAGE CAPACITY OF 365,000 ACRE-FEET

SCALE OF FEET
50 0 50 100





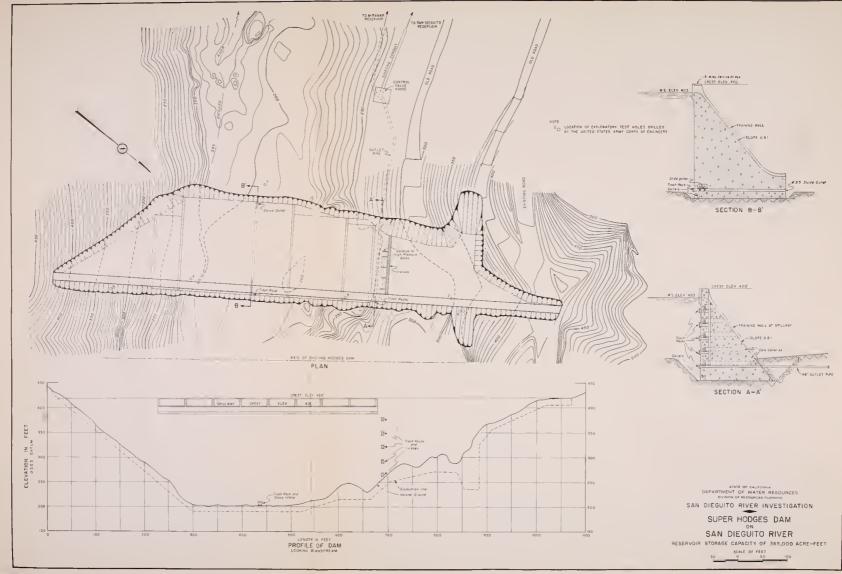


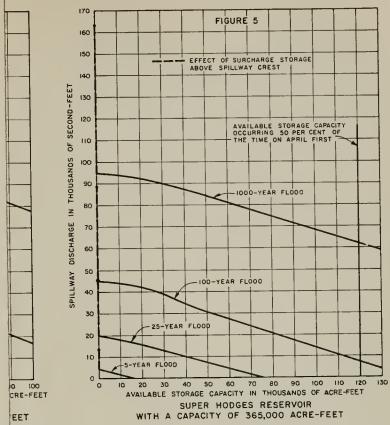
SAN DIEGUITO RIVER INVESTIGATION

SUPER HODGES DAM
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SAN DIEGUITO RIVER

RESERVOIR STORAGE CAPACITY OF 365,000 ACRE-FEET

SCALE OF FEET 50 0 50 10





TORAGE FOR FLOODS OF VARIOUS RECURRENCE INTERVALS

REDUCTION OF PEAK DISCHARGES BY EXISTING SUTHERLAND RESERVOIR WERE CONSIDERED NEGLIGIBLE.

PEAK DISCHARGES WERE REDUCED BY EXISTING HODGES RESERVOIR CONSIDERING SURCHARGE STORAGE ABOVE SPILLWAY CREST ONLY

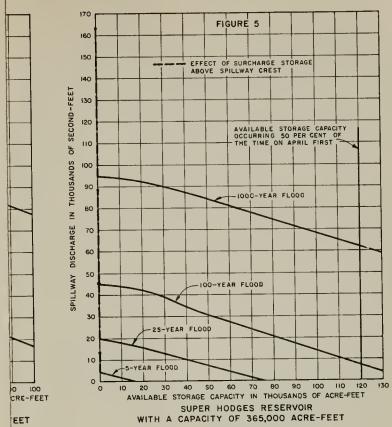
THE TERM "AVAILABLE STORAGE CAPACITY"
REFERS TO THAT PORTION OF THE GROSS
STORAGE CAPACITY THAT IS AVAILABLE FOR
FLOOD CONTROL PURPOSES.

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

SAN DIEGUITO RIVER INVESTIGATION

HYDROLOGY OF
CONTROL OF FLOODS BY RESERVOIRS OPERATED
FOR
WATER CONSERVATION PURPOSES
IN
SAN DIEGUITO RIVER WATERSHED





TORAGE FOR FLOODS OF VARIOUS RECURRENCE INTERVALS

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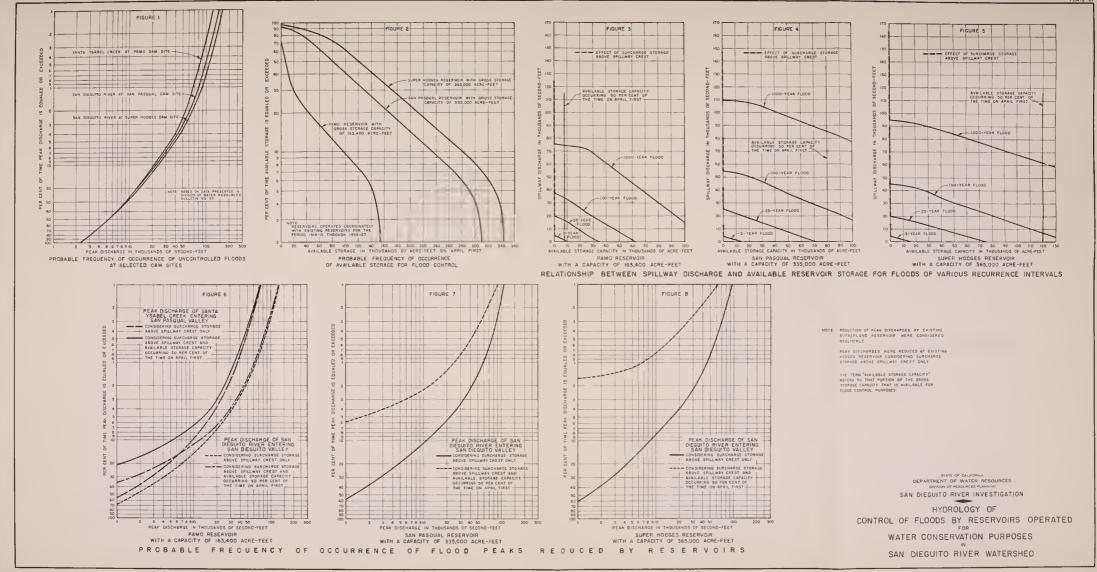
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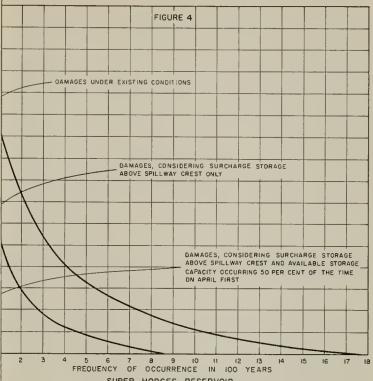
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STATE OF CALIFORNIA
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HYDROLOGY OF
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WATER CONSERVATION PURPOSES
IN
SAN DIEGUITO RIVER WATERSHED





SUPER HODGES RESERVOIR
WITH A CAPACITY OF 365,000 ACRE-FEET

SAN DIEGUITO VALLEY

OF PEAK DISCHARGES BY EXISTING NO RESERVOIR WERE CONSIDERED

HARGES WERE REDUCED BY EXISTING ESERVOIR CONSIDERING SURCHARGE ABOVE SPILLWAY CREST ONLY.

"AVAILABLE STORAGE CAPACITY"
) THAT PORTION OF THE GROSS
CAPACITY THAT IS AVAILABLE FOR
TROL PURPOSES

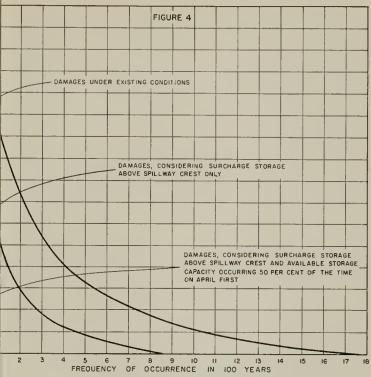
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SAN DIEGUITO RIVER INVESTIGATION

ECONOMICS OF
CONTROL OF FLOODS BY RESERVOIRS OPERATED
FOR
WATER CONSERVATION PURPOSES

SAN DIEGUITO RIVER WATERSHED





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WITH A CAPACITY OF 365,000 ACRE-FEET

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"AVAILABLE STORAGE CAPACITY"

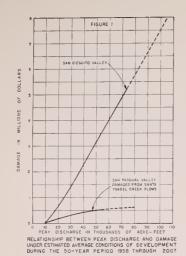
THAT PORTION OF THE GROSS
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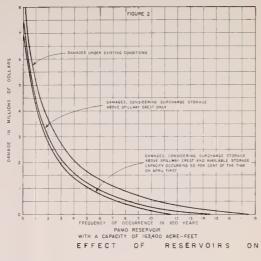
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

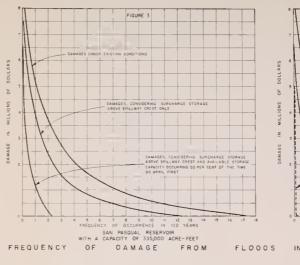
SAN DIEGUITO RIVER INVESTIGATION

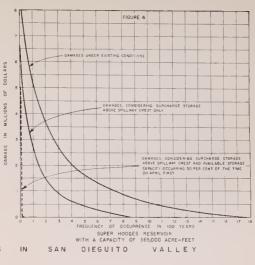
ECONOMICS OF
CONTROL OF FLOODS BY RESERVOIRS OPERATED
FOR
WATER CONSERVATION PURPOSES

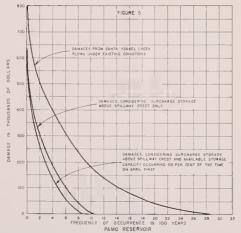
SAN DIEGUITO RIVER WATERSHED

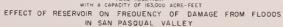


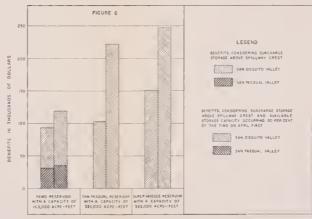












AVERAGE ANNUAL BENEFITS
CREDITABLE TO POTENTIAL WATER CONSERVATION RESERVOIRS

NOTE MEDUCTION OF PEAK DISCHARGES BY EXISTING SUTHERLAND RESERVOIR WERE CONSIDERED

PEAR DISCHARGES WERE REDUCED BY EXISTING HOODES RESERVOIR CONSIDERING SURCHARGE STORAGE ABOVE SPILLWAY CREST ONLY

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SYATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING

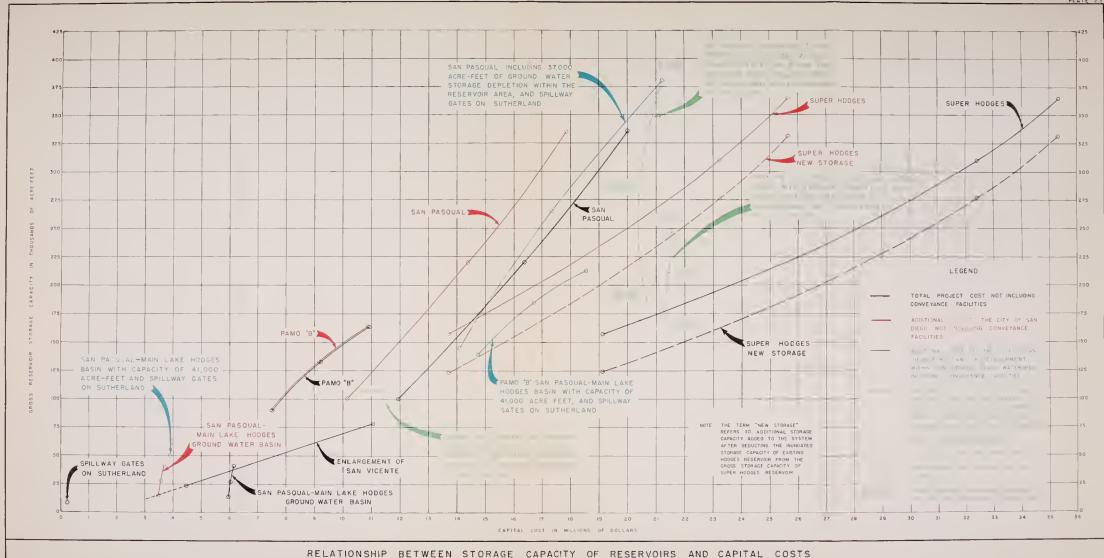
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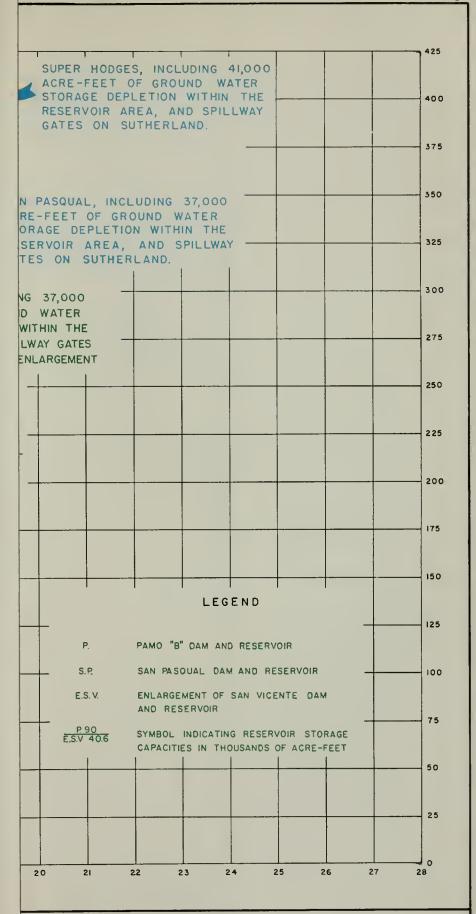
ECONOMICS OF
CONTROL OF FLOODS BY RESERVOIRS OPERATED

WATER CONSERVATION PURPOSES

SAN DIEGUITO RIVER WATERSHED

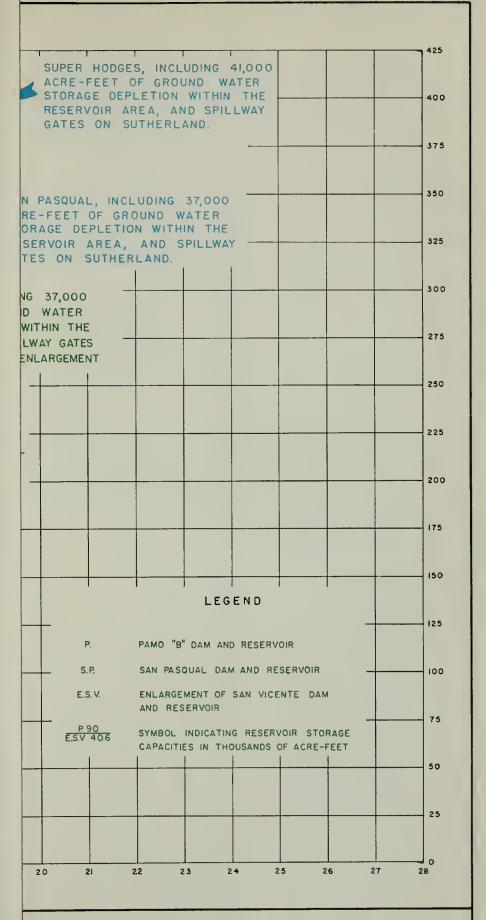




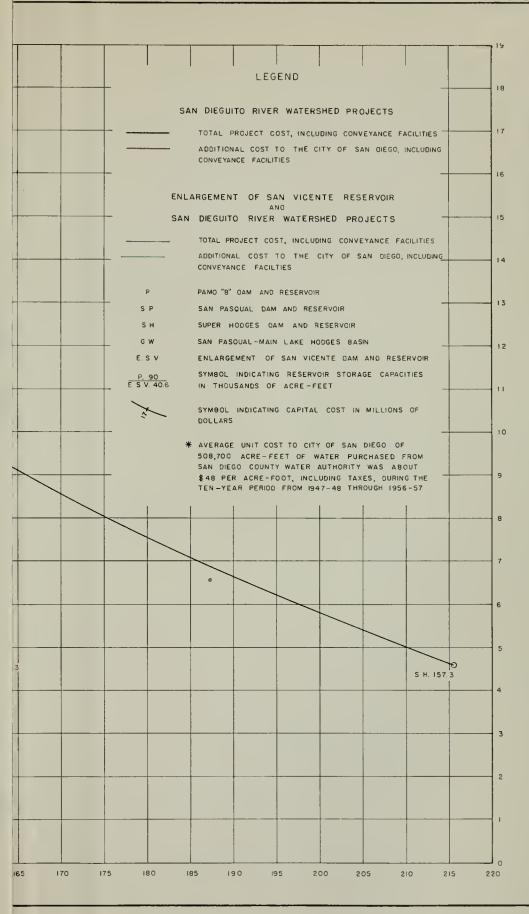


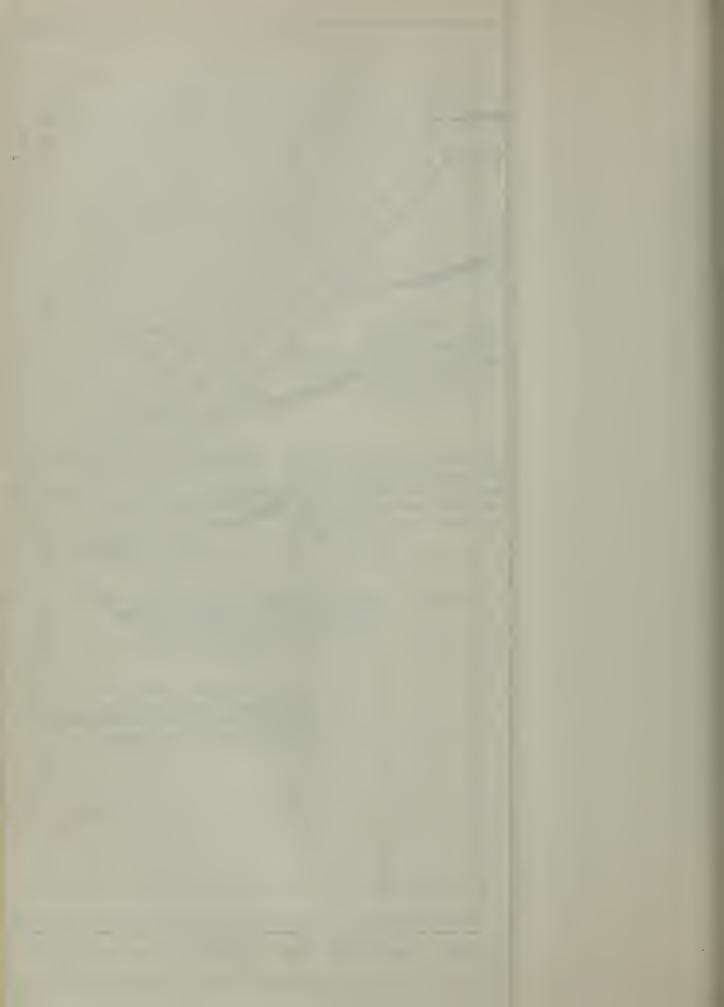
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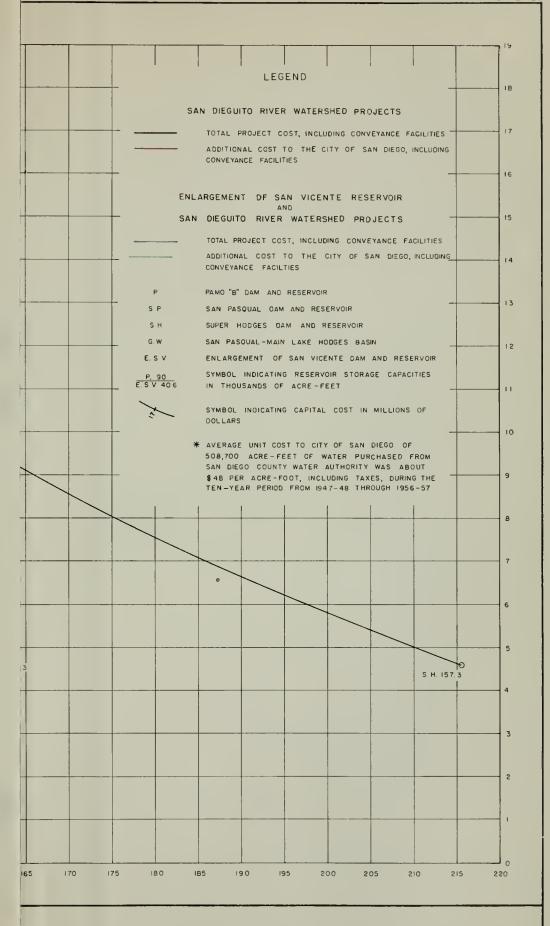


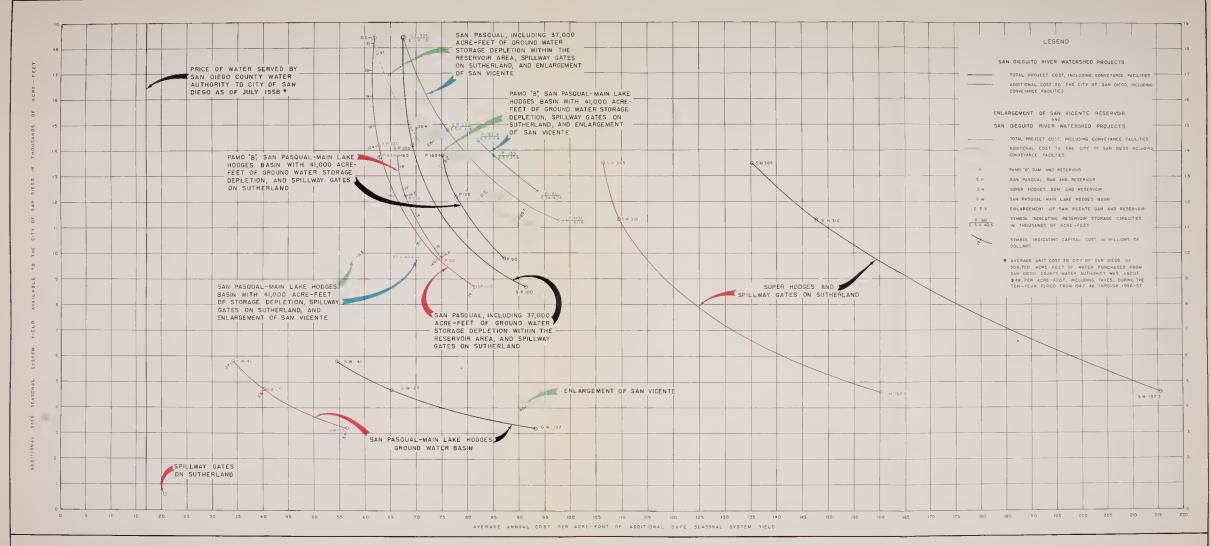


EASONAL SYSTEM YIELD









-V. 2 ITY OF EALIFORNIA IBRAHY STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

BULLETIN NO. 72

SAN DIEGUITO RIVER INVESTIGATION

VOLUME II

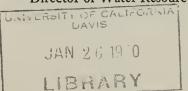
APPENDIXES

EDMUND G. BROWN
Governor



April, 1959

HARVEY O. BANKS Director of Water Resources





-V. 2

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

BULLETIN NO. 72

SAN DIEGUITO RIVER INVESTIGATION

VOLUME II

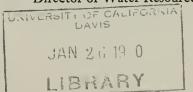
APPENDIXES

EDMUND G. BROWN Governor



April, 1959

HARVEY O. BANKS
Director of Water Resources





STATE OF CALIFORNIA DEPARTMENT OF WATER RESOURCES

BULLETIN NO. 72

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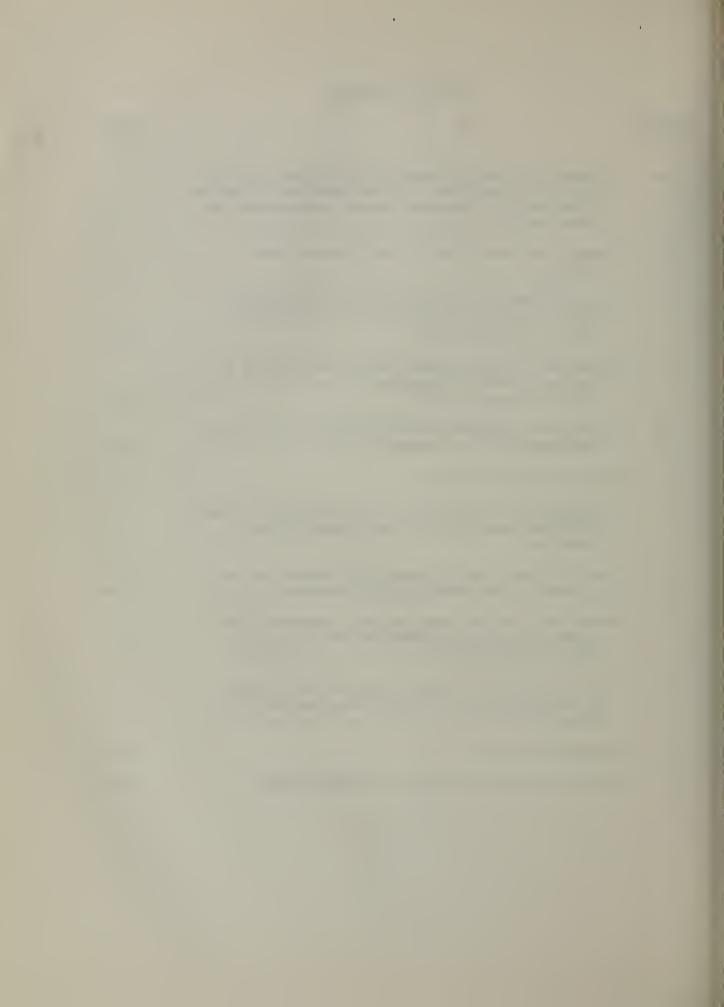
HARVEY O. BANKS Director of Water Resources

April, 1959



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APPENDIX A

AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE CITY OF SAN DIEGO, AND THE DEPARTMENT OF PUBLIC WORKS AND THE AMENDMENT THERETO, AUTHORIZING THE INVESTIGATION



AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE CITY OF SAN DIEGO, AND THE DEPARTMENT OF PUBLIC WORKS

THIS AGREEMENT, executed in quintuplicate, entered into as of the 1st day of July, 1956, by and between the State Water Resources Board, here-inafter referred to as the "Board", the City of San Diego, hereinafter referred to as the "City", and the Department of Public Works, State of California, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer":

WITNESSETH

WHEREAS, The Budget Act of 1956 (Chapter 1, Statutes of 1956) by Item 224 appropriated the sum of \$12,500 for the initiation of an investigation of water supply developments on the San Dieguito River; and

WHEREAS, by the State Water Resources Act of 1945, as amended, the Board is authorized to make investigations, studies, surveys, hold hearings, prepare plans and estimates, and make recommendations to the Legislature in regard to water development projects, including flood control plans and projects; and

WHEREAS, by said act, the State Engineer is authorized to cooperate with any county, city, state agency, or public district on flood control and other water problems and when requested by any thereof may enter into a cooperative agreement to expend money on behalf of any thereof to accomplish the purposes of said act; and

WHEREAS, the City has requested the Board to enter into a cooperative agreement to conduct a comprehensive investigation of water supply developments on the San Dieguito River; and

WHEREAS, the Board has requested the State Engineer to cooperate in conducting a comprehensive investigation of water supply developments on the San Dieguito River and to formulate a report thereon;

NOW, THEREFORE, in consideration of the premises and of the several promises to be performed by each as hereinafter set forth, the Board, the City, and the State Engineer do hereby mutually agree as follows:

ARTICLE I - WORK TO BE PERFORMED:

The work to be performed under this agreement shall consist of

(1) re-evaluation of plans of development of the San Dieguito River as

presented in Bulletin No. 55, "San Dieguito and San Diego Rivers Investigation", Division of Water Resources, 1949, (2) investigation of the

proposed development on the basis of the reservoirs being operated

independently of each other, and also on the basis of coordinated oper
ation with other developments currently supplying water to the City of

San Diego, and such other developments as may be contemplated for the

future, (3) investigation of combined operation of various surface storage

developments and utilization of the ground water storage capacity in San

Pasqual Valley with consideration of water rights which would be affected

thereby, (4) preliminary design and estimates of costs of proposed works,

(5) determination of the cost of acquisition of lands and rights of way

required for proposed works, and (6) economic comparisons of alternative

plans for water development.

The Board by this agreement authorizes and directs the State
Engineer to cooperate by conducting said investigation and formulating said
report and by otherwise advising and assisting in formulating solutions to
the water problems in San Diego County.

During the progress of said investigation, all maps, plans, information, data, and records pertaining thereto which are in the possession of any party hereto, shall be made fully available to any other party hereto for the due and proper accomplishments of the objectives hereof.

The work to be done under this agreement shall be diligently prosecuted with the objective of completing the investigation and report by June 30, 1958, or as nearly thereafter as possible.

ARTICLE II - FUNDS:

On execution of this agreement, the City shall transmit the sum of Twelve Thousand Five Hundred Dollars (\$12,500) to the State Engineer for deposit, subject to the approval of the Director of Finance, into the Water Resources Revolving Fund in the State Treasury, for expenditure by the State Engineer in performance of the work provided for in this agreement. Also upon execution of this agreement, the Board shall request the Director of Finance to approve the transfer of the sum of Twelve Thousand Five Hundred Dollars (\$12,500) from funds appropriated by the Board by Item 224 of the Budget Act of 1956 to the said Water Resources Revolving Fund for expenditure by the State Engineer in performance of work provided for in this agreement during the fiscal year 1956-57.

It is understood by and between the parties hereto that the sum of Twenty-five Thousand Dollars (\$25,000) to be made available as hereinbefore provided, is adequate to perform the above specified work during the fiscal year 1956-57, and it is the understanding that the City will make a further sum of Twelve Thousand Five Hundred Dollars (\$12,500) available at the commencement of the fiscal year 1957-58 which will be subject to a matching

contribution in an equal sum by the Board for the completion of said investigation and report, contingent upon the availability of City and Board funds for such purposes.

Notwithstanding anything contained in this agreement contrary
hereto or in conflict herewith, this agreement is made contingent upon the
funds being deposited in or transferred to the Water Resources Revolving
Fund as provided herein for expenditure by the State Engineer in performance
of the work provided for in this agreement. In the event any of the funds
are not transferred to the Water Resources Fund by the Director of Finance
as provided for herein within 30 days after the Board requests such transfer, this agreement shall terminate and the unexpended balance of any funds
deposited by the City shall be returned, provided that neither the Board
nor the State Engineer shall be obligated to the City for any portion of
the funds already expended.

The Board and the State Engineer shall under no circumstances be obligated to expend for or on account of the work provided for under this agreement any amount in excess of the funds made available hereunder.

Upon completion and final payment for the work provided for in this agreement, the State Engineer shall furnish to the Board and to the City a statement of all expenditures made under this agreement. One-half of the total amount of all said expenditures shall be deducted from the sum advanced from funds appropriated to the Board and one-half of the total amount of all said expenditures shall be deducted from the sum advanced by the City and any balance which may remain shall be returned to the Board and to the City in equal amounts.

Notwithstanding anything herein contained to the contrary, this agreement may be terminated and the provisions of this agreement may be altered, changed, or amended, by mutual consent of the parties hereto.

IN WITNESS WHEREOF, the parties hereunto have executed this agreement as of the date first herein written.

Approved as to Form and Procedure

CITY OF SAN DIEGO

J. F. DuPAUL, City Attorney

By /s/ Harold W. Reese
Asst. City Attorney
City of San Diego

By /s/ O. W. Campbell
City Manager

Approved as to Form and Procedure

FRED W. SICK (SEAL)

City Clerk

By /s/ Helen M. Willig Deputy

/s/ Mark C. Nosler
Attorney, Division of
Water Resources

STATE WATER RESOURCES BOARD

Approved as to Form and Procedure

By /s/ Clair A. Hill
Clair A. Hill, Chairman

Attorney, Department of Public Works STATE OF CALIFORNIA DEPARTMENT OF PUBLIC WORKS

APPROVED:

FRANK B. DURKEE
Director of Public Works

Director of Finance

By /s/ A. H. Henderson (SEAL)
A. H. HENDERSON
Deputy Director

Harvey O. Banks State Engineer

By /s/ T. R. Merryweather

Administrative Officer

DEPARTMENT OF FINANCE
A P P R O V E D
AUG 8 1956
JOHN M. PEIRCE, Director

By /s/ Louis J. Heinzer
Administrative Adviser

AGREEMENT BETWEEN THE STATE WATER RESOURCES BOARD, THE CITY OF SAN DIEGO, AND THE DEPARTMENT OF PUBLIC WORKS

This amendatory agreement, made and entered into as of the 30th day of June, 1958, by and between the State of California, acting by and through its Director of Water Resources, hereinafter referred to as the "State", and the City of San Diego, hereinafter referred to as the "City".

WITNESSETH

as the "Board", the City of San Diego, hereinafter referred to as the "City", and the Department of Public Works, State of California, acting through the agency of the State Engineer, hereinafter referred to as the "State Engineer", entered into a cooperative agreement as of the 1st day of July, 1956, whereby the State Engineer agreed to conduct a comprehensive investigation of water supply developments on the San Dieguito River and to formulate a report thereon, and the City and the Board agreed to share equally in the cost thereof; and

WHEREAS, the agreement provided that the work was to be diligently prosecuted with the objective of completing the investigation and report by June 30, 1958, or as nearly thereafter as possible; and

WHEREAS, it is estimated that additional funds in the amount of \$18,000, and an extension of time to December 31, 1958, will be needed to complete the investigation and report; and

WHEREAS, by Item 257 of the Budget Act of 1958 (Chapter 1, Statutes of 1958) the State Legislature appropriated funds for continuation of the investigation during the 1958-59 fiscal year; and

WHEREAS, it is the mutual desire of the parties hereto that the investigation and report be continued and completed on or before December 31, 1958; and

WHEREAS, pursuant to Article 1, Chapter 2, Division 1 of the California Water Code, the Department of Water Resources succeeded to and is vested with all of the powers, duties, purposes, responsibilities, and jurisdiction in matters within the scope of said original agreement of July 11, 1956, which were vested in the Department of Public Works, State of California, acting through the agency of the State Engineer, and the State Water Resources Board;

NOW THEREFORE, it is mutually agreed, subject to the availability of funds, that the original agreement is hereby amended as follows:

- (1) The time for completion of the investigation and report to be made under the original agreement is extended to and including December 31, 1958.
- (2) The City shall contribute \$9,000 for the continuation, during the period from July 1, 1958 to December 31, 1958 inclusive, of the work provided for by this agreement, which sum shall be transmitted to the State upon execution of this amendment.
- (3) The State shall contribute \$9,000 from funds appropriated to the Department of Water Resources by Item 257 of the Budget Act of 1958 for the continuation, during the period from July 1, 1958 to December 31, 1958 inclusive, of the work provided for by this agreement.
- (4) Except as herein amended the original agreement referred to above is continued in full force and affect.

agreement.

IN	WITNESS	WHEREOF,	the	parties	hereto	have	executed	this

Approved as to Form and Procedure

CITY OF SAN DIEGO

J. F. DU PAUL, City Attorney

By /s/ H. W. Reese
Assistant City Attorney
City of San Diego

Approved as to Form and Procedure

P. A. TOWNER

Chief Counsel, Department of Water Resources

APPROVED: DEPARTMENT OF FINANCE Sept. 19, 1958

T. H. MUGFORD Director of Finance

By /s/ Emil J. Relat
Senior Counsel

/s/ T. W. Fletcher
Assistant to the City Manager

City Clerk (SEAL)

STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

/s/ Harvey O. Banks
Harvey O. Banks
Director

RESOLUTION NO. 149109

1-11

BE IT RESOLVED, by the Council of the City of San Diego, as follows:

That the City Manager be, and he is hereby authorized and empowered to execute, for and on behalf of said City, an "Amendment to Agreement entitled 'Agreement between the State Water Resources Board, The City of San Diego, and the Department of Public Works'" providing for payment of additional funds in order to complete the investigation and report required under the original cooperative agreement with the State Water Resources Board, under the terms and conditions set forth in the form of Amendment to Agreement on file in the office of the City Clerk as Document No. 576368.

BE IT FURTHER RESOLVED, that the City Auditor and Comptroller is hereby authorized and directed to transfer the sum of \$9,000.00 within the Water Department Fund, from Unallocated Reserves, Account 500-230, to Non-Personal Expense, Planning and Investigation, Account 500-1005, to provide additional funds to cover the expense provided for under the above-mentioned agreement.

Presented by					
Approved as					
to form by	J.	F.	DuPAUL,	City	Attorney,
Ву					
				Chie	ef Deputy

M/7/25/58

Passed and adopted	by the Council	of The City of San Die	ego on July 31,
1958, by the follow	ring vote:		
YEAS Councilmen:	Williams, Sch	nneider, Kerrigan, Cur	ran,
	Evenson, Mayo	or Dail	
NAYS Councilmen:	None		
ABSENT- Councilman:	Tharp		
	AUTHENTICATEI	D BY:	
	Mayor of The	CHARLES C. DATL City of San Diego, Ca	lifornia
	rayor or me	or of or pair brego, oa.	LII OI III d
	City Clerk of	PHILLIP ACKER The City of San Diego	o, California
(SEAL)	Ву	ELFA F. HAMEL	Deputy
I HEREBY CERTIFY th	at the above ar	nd foregoing is a full,	, true and correct
copy of RESOLUTION	NO. 149109, pas	ssed and adopted by the	e Council of The
City of San Diego,	California July	7 31, 1958.	
	City Clerk of	PHILLIP ACKER The City of San Diego	, California
(SEAL)	By /s/	ELFA F. HAMEL	Deputy

APPENDIX B

GEOLOGY AND GROUND WATER
OF
SAN DIEGUITO RIVER WATERSHED

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APPENDIX B

GEOLOGY

CHAPTER B-I. INTRODUCTION

This geologic investigation was limited to the San Dieguito River watershed, which includes an area of approximately 345 square miles within the coastal portion of San Diego County. This appendix presents the results of the geologic studies, with particular emphasis placed upon those geologic features which influence the occurrence and movement of ground water.

The geologic studies were conducted as a part of the investigation of conservation developments on the San Dieguito River and its tributaries undertaken in cooperation with the City of San Diego. Its purpose is threefold, namely:

- 1. To describe the geology and water-bearing characteristics of the rocks.
- 2. To discuss the effects of geologic structure upon the movement of ground water and the infiltration of sea water, and to describe briefly the history of events involved in the evolution of the principal structures.
- 3. To describe the procedures followed in estimating the changes in ground water storage and subsurface ground water movement that occurred within the principal basins during selected periods of study.

In order to accomplish the foregoing objectives, water wells in the area were located, measurements of depths to ground water and mineral analyses of surface and ground water were made and evaluated, and all available well logs were collected and analyzed. Geologic cross sections were constructed to show the configuration of the bottom of the basins and are shown on Plates 6-A and 6-B. In field mapping, particular care was given to the location of boundaries between water-bearing materials and nonwater-bearing materials.

Since this was primarily a study of ground water, the nonwaterbearing rock areas were not investigated in detail. Work in this regard was limited to compilation of previous investigations and field checking, when needed, to coordinate the works of various authors.

The older, less permeable, formations which yield little water are treated briefly. These rocks are mentioned because in locations where they occur they affect the chemical character and quality of the ground water. They influence the movement and occurrence of ground water, and they form or delimit, in part, the ground water basins in the Coastal Hydrologic Unit.

The permeable water-bearing formations are described in greater detail. These deposits comprise the fill of the ground water basins, the principal sources of ground water in the watershed.

Subsurface geology was interpreted largely from water well logs which were obtained from drillers and owners. Ground water level data and water analyses were amassed, and in certain areas the transmissibility of the sediments was estimated by field tests using pumping wells. All of these data were drawn upon freely in interpreting the geology. Existing published and unpublished reports were utilized in the preparation of this appendix and are listed in the accompanying bibliography.

In the course of this investigation, a geologic map was prepared by compiling data from existing geologic maps, from aerial photographs, and from field mapping by personnel of the State Department of Water Resources. The map presented as Plate 5 was prepared to provide a sound basis for determination of the extent and nature of the water-bearing materials.

CHAPTER B-II. PHYSIOGRAPHY

The San Dieguito River watershed is located in the Peninsular Range Geomorphic Province. The area ranges from sea level on the western extreme to over 5,700 feet elevation on the eastern end of the watershed at Mount Volcan. The topography of the region as a whole may be divided into the highland region and the coastal belt, each with a general northwest trend (Miller, 1935a). The San Dieguito River is just one of the many westward flowing streams in San Diego County that drains into the Pacific Ocean.

Viewed in a broad way, the mountainous region of the San Dieguito
River watershed may be looked upon as an eroded fault block which slopes
toward the southwest and is dissected by many streams. The highland area
stands out in the form of more or less well defined old erosional surfaces,
separated by numerous gorges and canyons. The eastern front of the highlands,
corresponding to the most easterly extent of the watershed, is a high steep
eroded fault scarp, representing the southeasterly extension of the Elsinore
fault system (Miller, 1935a). Transverse faults, associated with the
Elsinore fault system, mark the sites of some of the major valleys in the
watershed. Within this area, the outstanding highland valleys are: Santa
Ysabel Valley at an elevation of about 3,000 feet, Upper Guejito Creek area
at 2,000 feet, and the Ramona area at about 1,400 feet. Pamo Valley marks
an eroded fault zone and San Pasqual Valley possibly a system of faults.

The coastal area is a northwest trending band of marine and nonmarine sediments, about six miles wide, which lies between the ocean and the igneous and metamorphic rocks of the highland area. Before erosion occurred, these sediments formed a flat, featureless area, remnants

of which may be seen along ridge tops. Remnants of old terraces are found near the contact of sediments with the highland area. Overlying the sediments near the ocean are erosional remnants of old longitudinal beach ridges formed as sea level receded (Hanna, 1926). The most prominent topographic expression in the coastal area is the San Dieguito Valley which was eroded by the ancient superimposed San Dieguito River and later backfilled to a depth of at least 200 feet. The valley walls rise precipitously from 100 to 300 feet above the flat valley floor. As is usual in this type of semiarid climate, the southern wall of this east-west trending valley is steeper than the opposite side and more densely covered with native vegatation.

The sea floor in the San Diego-La Jolla area has been explored extensively by the Scripps Institute of Oceanography, in cooperation with the United States Navy, from 1943 to the present. In that area, two major submarine canyons cutting the continental shelf have been discovered and explored.

The shelf off the mouth of the San Dieguito River is relatively featureless and unexplored. The continental shelf in this area is about two and one-half miles wide, with a maximum depth of about 500 feet at its western edge (Shepard, 1952). The continental shelf in the San Diego-La Jolla area has been formed on truncated beds of soft shales, limestones, and conglomerate. These beds have been correlated with the Tertiary beds on shore. A veneer of gravel and sand, probably of Pleistocene age, unconformably overlies the Tertiary sediments (Shepard, 1941). This probable holds true for the San Dieguito River area as well.

During the last glacial period, when sea level was about 300 feet feet lower than the current level and the San Dieguito River was actively excavating its channel, the valley extended for some distance across the

shelf. With the postglacial rise of sea level the stream backfilled its channel to its present level. The old backfilled channel undoubtedly still extends across the continental shelf, filled now with sediments which are in direct hydraulic continuity with the ocean.

CHAPTER B-III. GEOLOGIC HISTORY

The geologic history of the San Dieguito River drainage area is one of some complexity, with many unrecorded chapters. A summary description of the formations and their relative ages is presented in Chapter B-IV.

The pregranitic rocks include the Santiago Peak Volcanics and associated sediments as well as older rocks of which little is known.

These materials have been metamorphosed by injection of granitic magmas in Jurassic and Cretaceous times. Injection was accompanied by uplift and followed by erosion, removing most of the pregranitic materials.

Although there are no Cretaceous sediments exposed in this area, the great thickness of marine sediments penetrated by wells near the present shore line suggests that deposition may have occurred during middle to upper Cretaceous and possibly during the Paleocene.

Throughout Cretaceous and Eocene time, erosion in the crystalline rock area was developing a more or less subdued erosional surface. Remnants of the surface are found throughout San Diego County. Materials eroded from the highland areas during late Cretaceous to late Eocene time were deposited mostly as marine sediments near the present shore line. By the end of the Eocene, several hundred feet of sediments had been deposited near the present shore line. Following Eocene deposition a slight regional upwarping of the land and considerable erosion occurred. Formation of "V" shaped valleys was probably initiated at this time.

During the Miocene, the sea intruded upon the land, as is evident in other areas. In Pliocene and/or Pleistocene time, the sea receded in stages, developing prominent wave cut terraces. Part of the apparent movement was probably due to uplift of the land. As the sea receded,

longitudinal beach ridges, which are now deeply dissected by erosion, were formed on the terraces. At the time of terrace development, the San Dieguito River was a meandering stream flowing across the surface of the Eocene sediments, and the "V" shaped valleys were undergoing further erosion.

During Pleistocene time, the San Dieguito River entrenched its channel about 500 feet into the Eocene sediments along the coast. This simple picture of downcutting was greatly complicated by several eustatic fluctuations of sea level, caused by melting and forming of the continental ice sheets. With the changes of sea level, several sets of terraces were formed in San Dieguito Valley.

During the last glacial period (Wisconsin), sea level was about 300 feet below present sea level and coastal valleys were deeply eroded. Since Wisconsin time, sea level has raised causing deposition of sediments in the coastal portion of the region. During the 11,000 to 15,000 years (Shepard and Suess, 1956) following Wisconsin glaciation, movement of the land has apparently been negligible. Inland valleys were also being developed during the glacial and interglacial periods of Pleistocene time. Changes in climate and movements of the land probably caused the development of terraces in Pamo and San Pasqual Valleys.

The most recent activity has apparently been a slight relative rise in sea level, causing lagoonal conditions in the coastal area. Youthful gullies found in much of the watershed may be caused by a change in climate or by man's activities or both. Earthquakes in the region indicate that tectonic activity is still in progress, but surface expression of active faulting has only been noted in the Elsinore fault system.

CHAPTER B-IV. GEOLOGIC UNITS

The water-bearing formations in the San Dieguito River watershed are divided for convenience and ease of description into the following:

(1) permeable materials; (2) semipermeable materials; and (3) fractured rock. Brief descriptions and ages of formations are given on Table B-1 and in the legend of Plate 5. Areal extent of the formations is shown on Plate 5, entitled "Areal Geology".

TABLE E-1
STRATIGRAPHIC COLUMN FOR SAN DIEGUITO RIVER WATERSHED

Age		:	Name of unit	Symbol	Thickness	Description
			Alluvium	Qal.	0-200 feet	Gravel, sand, silt and clay
Cenezoic	Quaternary	Recent	Beach and dune sand	Qd	0-100 feet	Sand and ironstone concretions
		R	Residuum	Qr	0-100 feet	Clayey sand with boulders of weathering
	Tertiary	Eocene	Poway conglomerate	Tepc	0-100 feet	Gravel, sand and clay
	101 0101	Eoc	La Jolla formation	Telj	1500-1800 feet	Sand, shale, some gravel
	Cretaceous		Leucogranodiorite	__ Klg		Light grey medium grained, variable
			Granodiorite	Kgr		Light colored with flakes of dark minerals
			Tonalite	Kt		Dark, coarse grained
			Gabbro	Kg		Dark, coarse grained
Megoic,	Jurassic		Jurassic slates	Js		Interbedded with Santiago Peak Volcanics
Mee			Stonewall granodio- rites and associated metamorphics	Jst		Quartzite, gneiss, schist and grano- diorite
			Santiago Peak Volcanics	Jsp		Mildly metamorphosed agglomerates, shales quartzites, tuffs
			Intrusives related to Santiago Peak Volcanics	Jspi		Fine grained grey to black grano- diorite and basalt
	Triassic		Bedford Canyon formation and Julian schist	Tr		Slates, argillites quartzites, limestone, and schist

Permeable Materials

Permeable materials discussed below include three geologic units:

Recent alluvium, Beach and Dune Sands, and residuum. The alluvium was deposited as valley fill, while the residuum was developed as a weathering product of the underlying crystalline rock. Both the alluvium and residuum transmit water to pumping wells, but the yield of wells in the alluvium usually exceeds the yield of wells in the residuum. Beach Sands are in contact with the ocean and probably contain sea water. The Dune Sands lie entirely above the water table and hence contain no usable water.

Recent Alluvium

Recent alluvium is found in the valleys of all of the principal streams along the coast. These stream valleys were excavated at a time when sea level was as much as 300 feet lower than at present, thus permitting the streams to excavate their ancestral channels. Since this time of deep erosion, there has been a rise in sea level which caused the streams to aggrade their valleys.

The alluvium is composed of gravel, sand, and clay derived from the drainage basins of the streams. In the inland valleys it was probably deposited due to factors other than change in sea level, such as regional tilting or climatic changes. Alluvium is the most important source of ground water for irrigation and domestic purposes.

Beach and Dune Sands

The beach and dune sands occur along the western margin of the San Dieguito River watershed. Because the beach sands are in contact with the ocean, and probably contain sea water, they were not considered in the hydrologic balance. Elongate dune ridges trend generally in a north-south

direction, parallel to the coast. These dune sands are believed to lie entirely above the water table and hence yield no water to wells.

Residuum

Most of the igneous rocks in San Diego County are coarse grained granitics which yield readily to weathering. In the highland areas where these rocks occur; the surface is immediately underlain by residuum, commonly known as decomposed granite.

The granitic rocks, especially tonalite, weather to a well developed residual soil exhibiting four stages or zones. The first or most weathered zone is a structureless sandy clay or clayey sand, usually with no boulders of weathering. In the second zone, the boulders of weathering are subordinate, rounded, and surrounded by sandy clay and comprise less than 50 per cent of the volume. In the third zone, the boulders are dominant, rectangular, and locked. Here they comprise 50 to 90 per cent of the volume. In the fourth zone, the least weathered, there is minor residual debris along the major structural planes which may be considerably iron stained (Ruxton, 1957). Decomposition is most advanced at the surface where the rock has been completely reduced to soil and it decreases downward to the solid granite at depths in some areas to well over 100 feet. Residuum is considered as Quaternary age in this report; although it is reasonable to assume that the residuum was also formed during much of the Tertiary period.

Although the yield of wells in the residuum is comparatively low, it is widespread and was mapped as a water-bearing unit in this investigation. Nearly all of the granitic rock areas have at least a thin discontinuous vineer of residuum on them. In many instances, the residuum lies above the ground water surface and is not a significant contributor of ground water.

Semipermeable Sediments

Semipermeable sediments are those which generally yield only enough water for limited domestic use and which may contain water of poor quality. The Poway conglomerate and the La Jolla formation are geologic units included in this group and are both of Eccene age.

Poway Conglomerate

The Poway conglomerate consists of lenses of conglomerate, sand, and clay and is capped by a thick bed of rounded pebbles and boulders up to three feet in diameter. Some of the clays have yielded marine fossils, but the Poway is considered to be mostly of nonmarine origin (Hertlein, 1954, Bellemin and Merriam, 1958). Because of its dense character and position, generally above the ground water surface, no known water is derived from this formation. Due to tight cementation and dense cobbles the conglomerate is ordinarily difficult to drill. The Poway conglomerate ranges up to 100 feet in thickness in most of the areas of outcrop in the San Dieguito River watershed.

La Jolla Formation

The La Jolla formation of Eocene age underlies the Poway conglomerate and consists of the following three members in upward succession:

(1) the Del Mar sand; (2) the Torrey sand; and (3) the Rose Canyon member. These members are not differentiated on Plate 5. The Del Mar sand, about 200 feet thick, is a greenish-grey or reddish, poorly consolidated sand and sandy shale, and is fossiliferous near the coast. It is often lenticular, cross bedded and is of both nonmarine and marine origin (Hanna, 1926). The Torrey sand is white to light grey or brown in color, massive, clean, apparently without fossils, and about 100 feet thick. The Rose Canyon member is

composed mostly of marine and nonmarine sands with minor amounts of gravel and clay. Verbal communication with Dean Milow of San Diego State College (1958) indicates that he considers the Rose Canyon member as a formation having a maximum thickness of about 1,500 feet.

The La Jolla formation yields water from all of its sands and gravels, but only in minor amounts, and few wells are drilled into it. The water is mostly very poor in quality and is probably a mixture of saline connate water and slowly percolating meteoric water.

The La Jolla formation is slightly distorted and dips gently east-ward overlapping the igneous rocks to the east. Faulting is common throughout the coastal area with small displacements. Data are not available to determine whether significant barriers to movement of ground water exist in this area.

Underlying the La Jolla formation and extending to great depths are sediments which may be Paleocene or Cretaceous in age. These older sediments are, however, of little consequence because water contained therein is not presently being put to beneficial use.

Fractured Rock

The fractures, crevices and joint systems in massive rock sometimes yield water to wells. While wells generally obtain only limited supplies from this source, the water obtained is usually of good quality and is used widely for domestic purposes.

Wells have probably been drilled into all of the granitic rock units described hereinafter. Of these rocks, tonalite yields the greatest quantity of water because it is usually overlain with a mantle of residuum which retains ground water and acts as a storage reservoir for the fractures.

Descriptions of the following rock types are taken largely from,

Larsen, Jr., E. S., Everhart, D. L. and Merriam, Richard, "Crystalline Rocks

of Southwestern California", Department of Natural Resources, Division of Mines,

Bulletin No. 159, 1951.

Leucograndiorite

Leucograndiorite is limited in areal extent. It is fine grained, very light grey on fresh surfaces, and yellowish on weathered surfaces. The light colored outcrops show rounded boulders of weathering with meager soil cover. The boulders are not as prominent as the boulders of weathering of the granodiorites. Leucogranodiorite is imprevious and yields water only from fractures and joints.

Granodiorite

Granodiorite comprises the most rugged outcrops of the area. It forms grey to white boulders of weathering as large as 15 feet in diameter. Most of the area of greatest relief is underlain by granodiorite. Hand specimens reveal abundant tablets of white feldspars and some small flakes of biotite in a fine-grained groundmass. Granodiorite is impervious and yields water only from fractures and joints.

Tonalite

Tonalite or quartz-diorite is a medium grained, grey to dark grey rock, and shows characteristic outcrops of boulders of weathering in a deeply weathered matrix. Soils in tonalite areas are generally darker red than in other rock type areas. The dark grey boulders are often weathered completely free from the parent rock and are common in the outcrop area. Most of the low brush covered hills with many rounded bouldery outcrops are underlain

by tonalite. Although the tonalite itself is impervious, except for fractures and joints, it is the source of the deepest residuum from which large quantities of water are extracted.

Gabbro

Gabbro occurs locally in many areas. The outcrops are uniformly massive, grey to black, and usually show a banding or streaking of white or clear feldspars. Residual soils form on the gabbro in much the same manner as on the tonalites, but the soil is not as deep as the latter and the color is characteristically darker. Gabbro is impervious and yields water only from fractures and joints.

Jurassic Slates

Jurassic slates are interbedded with the Santiago Peak Volcanics. They are thin bedded, dark grey in color, and slabby in outcrop with little or no soil cover. These slates would yield water only from fractures and joints, although no wells are known to penetrate them.

Stonewall Granodiorites and Associated Metamorphics

These rocks form bold, light grey outcrops. They include grano-diorite gneiss, slate, schist, and quartzite. Much of this older crystalline and metamorphic rock has been deeply weathered to a well developed residuum. These rocks are impervious and yield water only from fractures and joints.

Santiago Peak Volcanics

Santiago Peak volcanics are a mildly metamorphosed series of agglomerates, shales, quartzites, tuffs, red and black andesites, and quartz latites. There are also some rhyolites, as little slate, and probably

some basalts. The outcrops are slabby to blocky with little residual soil cover.

The steeper slopes are generally talus covered. The Volcanics are impervious

and yield water only from fractures and joints.

Intrusives Related to the Santiago Peak Volcanics

These intrusives are believed to be of the same age as the Santiago Peak volcanics and are usually small bodies of granodiorite and related rocks. They are, for the most part, fine-grained rocks which form blocky to subangular outcrops and the cores of small rocky hills. These rocks are impervious and yield water only from fractures and joints.

Bedford Canyon Formation and Julian Schists

These rocks are mildly metamorphosed slates and argillites with some quartzites and schists and a few thin lenses of limestone. They often form bold, steep outcrops, and are penetrated by pegmatites which carry gold and semiprecious gem minerals. These rocks are impervious and yield water only from fractures and joints.

CHAPTER B-V. STRUCTURE

On the eastern end of the San Dieguito River watershed is a high, steep, eroded scarp forming the western side of Volcan Mountain. This scarp represents the southeasterly extension of the Elsinore fault system, which has been active at least since Tertiary time. Associated with this great fault are many minor transverse faults (Saver, 1929). The summit of this fault block is generally a well preserved erosional surface into which streams have cut many gorges and canyons (Miller, 1935). Some of the canyons have been eroded into rocks weakened by transverse faults.

Although there are a great many faults in the area, only a few of them are easily mapped. Most of the faults are evidenced only by topographic features such as alignment of saddles, springs, offset drainage patterns, or "V" shaped valleys.

Of the numerous structural features in the region, only Temescal fault significancyly effects ground water movement. This fault extends through Pamo Valley and into Ramona Basin. It is evidenced by an alignment of saddles at both ends of Pamo Valley, a brecciated zone on the southern edge of Ramona Basin, and an alignment of rock outcrops across the basin. Ground water contours indicate that the fault forms a partial barrier to the free movement of ground water, which has resulted in the formation of numerous springs in the fault zone. Well logs also indicate the approximate location of the fault zone, shown on Plate 6-B, and water of poor mineral character is obtained from wells in this zone.

The frequent movements of the fault blocks have fractured the rocks extensively. It is probable that in this region there are fractures or joints in every crystalline rock. Wells penetrating these bodies of rock may intersect these fractures, and appreciable quantities of water are occassionally

obtained in this manner. Water found in bedrock is derived from deep penetration of meteoric water.

The Eocene sediments near the coast have been tilted slightly land-ward since their deposition (Hertlein, 1943) and are gently folded. There are many minor faults in the coastal sediments, which appear to be local, normal faults with displacements in the range of tens of feet.

CHAPTER B-VI. DESCRIPTION OF GROUND WATER BASINS

There are five ground water basins in the San Dieguito River watershed of sufficient size or importance to merit investigation, and they are discussed at some length in this chapter. Fifteen smaller bodies of alluvium or residuum are also briefly described herein.

In areas surrounded by Eocene sediments, the extent of the water-bearing alluvium was easily delimited at the contact between the alluvial fill and the adjoining sediments. In the valleys cut in crystalline rock and filled with alluvium, the boundaries of the water-bearing material are somewhat more indefinite, due to the presence of residuum on the surrounding slopes. The residuum has, in many cases, slid or washed onto the alluvium masking the exact contact. In many instances, a part of the residuum was included in the ground water basin.

The highland valleys containing residuum presented the greatest problem in establishing a ground water basin boundary since, in most cases, the residuum continues from the basin into the adjoining hills where it is usually above the water table. The following criteria were used for including residuum within a ground water basin: (1) presence of wells; (2) relatively gentle ground slope; and (3) lack of outcrops.

To facilitate discussion, the basins are described under the hydrologic unit in which they occur. Location of ground water basins are shown on Plate 4. Descriptions of these basins are shown in Table B-2 and the characteristics and other pertinent data are contained in Table B-3. Table 10, page 57, in Volume I, lists the number of active wells and ground water extractions from basins in San Dieguito River watershed.

DESCRIPTION OF GROUND WATER BASINS

; Sescription		San Dieguito Basin is bounded and underlain by Eocene sediments and filled with Recent alluvium. Most of the wells extract water from the Alluvium with only a few producing from the adjoining sediments. The San Dieguito River drains the basin westerly into the ocean.	La Jolla Basin is bounded and underlain by Eocene sediments and volcanic rocks and is filled with Recent alluvium. One well extracts water from the alluvium with only a few producing from the adjoining sediments. This valley is constricted near the middle by an outcrop of volcanic rocks. Iusardi Creek drains the basin westerly into the San Dieguito Basin.		San Pasqual Basin is bounded and underlain by igneous and metamorphic rocks and is filled with Recent alluvium. Most of the wells extract water from the alluvium with only a few producing from the adjoining igneous rocks. Very few of the wells in the alluvium reach bedrock. The San Dieguito River drains the basin westerly into the Hodges Basin.	Lake Hodges Basin is bounded and underlain by igneous and meta- morphic rocks and is filled with Recent alluvium. Most of the wells extract water from the residuum which is developed on the igneous rocks. The westerly portion of the basin is occupied by Lake Hodges. The San Dieguito River drains the basin westerly into Lake Hodges.
Basin	Coastal Hydrologic Unit	San Dieguito	La Jolla	Central Hydrologic Unit	San Pasqual	Lake Hodges

DESCRIPTION OF GROUND WATER BASINS (continued)

	Description	
0	•	(cont.)
	Basin	Central Hydrologic Unit (cont.

Felicita

rocks. Tributaries to the San Dieguito River drain the basin southerly from the residuum with only a few producing from the fractured igneous Felicita Basin is bounded by igneous rocks and underlain by residuum which has developed on these rocks. Most of the wells extract water into Lake Hodges Basin.

which has developed on these igneous rocks. Most of the wells extract shed divide and gets very little recharge from the surrounding areas Tributeries to the San Dieguito River drain the basin northerly into the igneous rocks. This basin is bounded on the south by the waterwater from the residuum with only a few producing from fractures in Green Basin is bounded by igneous rocks and underlain by residuum Lake Hodges Basin.

with Recent alluvium. Wells extract water from the alluvium and the Hidden Basin is bounded and underlain by igneous rocks and is filled adjoining igneous rocks. Bach Creek drains the basin westerly into Reed Basin.

Hidden

Reed

Green

extracts water from the alluvium. Bach Creek drains the basin southwith Recent alluvium. There is one active well in the basin, which Reed Basin is bounded and underlain by igneous rocks and is filled westerly into the San Fasqual Basin.

DESCRIPTION OF GROUND WATER BASINS (continued)

Description		East Guejito Basin is bounded by igneous rocks and underlain by residuum which has developed on these rocks. In this basin there is a very thin covering of alluvium along the stream course; however, none of the water in this alluvium is utilized. Guejito Creek drains the basin southerly into San Pasqual Basin.	West Guejito Basin is bounded by igneous rocks and underlain by residuum which has developed on these rocks. In this basin there is a very thin covering of alluvium along the stream course, but none of the water in this alluvium is utilized. Guejito Creek drains the basin southerly into San Pasqual Basin.	Highland Basin is bounded by igneous rocks and underlain by residuum which has developed on these igneous rocks. Wells extract water from the residuum and from fractures in the igneous rocks. A tributary to to the San Dieguito River drains the basin southwesterly into Lake Hodges Basin.
••••	(cont.)			
Basin	Central Hydrologic Unit (cont.)	East Guejito	West Guejito	Highland

Inland Hydrologic Unit

Ramona

from the residuum with only a few producing from fractures in the igneous retards the westward movement of ground water. Clevenger Creek and Santa rocks. Temescal Fault extends through the eastern end of the basin and which has developed on these rocks. Most of the wells extract water Ramona Basin is bounded by igneous rocks and underlain by residuum, Maria Creek drains the basin northwesterly into San Pasqual Basin.

water from the residuum with only a few producing from the fractured igneous rocks. Hatfield Creek drains the basin westerly into Upper Hatfield Basin.

TABLE B-2

DESCRIPTION OF GROUND WATER BASINS (continued)

Description	Unit (cont.)	Pamo Basin is bounded and underlain by igneous rocks and is filled with Recent alluvium. Most of the wells extract water from the alluvium with only a few producing from the adjoining igneous rocks. Temescal Fault runs the length of the basin but has no effect on the ground water movement. Temescal Creek drains the basin southwesterly into San Pasqual Basin.	Lower Hatfield Basin is bounded by igneous rocks and underlain by residuum. which has developed on these rocks. Water is extracted from the residuum. Hatfield Creek drains the basin southwesterly into Ramona Basin.	Upper Hatfield Basin is bounded by igneous rocks and underlain by residuum. which has developed on these rocks. Water is extracted from the residuum. Hatfield Creek drains the basin southwesterly into Lower Hatfield Basin.	Wash Hollow Basin is bounded by igneous rocks and underlain by residuum which has developed on these rocks. All of the wells extract water from the residuum. Wash Hollow Creek drains the basin westerly into Lower Hatfield Basin.	Deller to be the best to be the topologie and metamounts and underlain by
Doct	Inland Hydrologic	Pamo	Lower Hatfield	Upper Hatfield	Wash Hollow	

DESCRIPTION OF GROUND WATER BASING (continued)

East Santa Teresa West Santa Teresa Santa Ysabel
--

TABLE B-3
GROUND WATER BASIN CHARACTERISTICS

Alluvium 50 Alluvium 50 Alluvium 50 Alluvium 70 Alluvium 50		40 41	Two	. Retimeted expenses	000000000000000000000000000000000000000	Hochio	Maximum depth
## 3,910 Alluvium 120 63,000 8,000 510 Alluvium 50 3,600 2,500 3,350 Alluvium 120 73,000 37,000 3,350 Alluvium 70 16,000 11,000 4,150 Residuum 70 23,000 16,000 1,030 Alluvium 50 1,200 900 1,030 Alluvium 50 1,200 900 1,200 Alluvium 50 1,300 900 1,200 Alluvium 50 1,300 9,000 1,200 Alluvium 50 1,400 50,000 1,200 Alluvium 50 1,400 1,000 1,000 1,000 500 1,200 Alluvium 50 1,400 1,400 500 1,000 1,				depth of material,	capacity, in acre-feet*	capacity, in : acre-feet**	to ground water in feet Fall, 1957
3,910 Alluvium 120 63,000 8,000 610 Alluvium 50 3,600 2,500 3,430 Alluvium 120 73,000 37,000 3,430 Alluvium 40 22,000 10,000 3,400 Residuum 70 23,000 11,000 1,150 Alluvium 50 1,200 1,200 1,030 Alluvium 50 1,200 4,800 1,030 Alluvium 50 1,200 4,800 1,780 Alluvium 50 1,300 900 1,290 Alluvium 50 1,300 900 1,290 Alluvium 50 1,300 900 1,290 Alluvium 50 1,300 9,000 350 Residuum 50 1,2,900 9,000 1,290 Alluvium 50 1,900 9,000 350 Residuum 50 1,2,900 9,000 350	stal Hydrologic Unit						
610 Alluvium 50 3,600 2,500	San Dieguito	3,910	Alluvium	120	63,000	8,000	96
3,430 Alluvium 120 73,000 37,000 3,350 Residuum 70 16,000 11,000 1,000 11,000 1,000 11,000 1,030 Alluvium 50 1,000 1,000 1,030 Residuum 50 6,900 4,800 1,780 Alluvium 50 1,900 50,000 1,290 Alluvium 50 1,900 50,000 1,290 Alluvium 50 1,900 50,000 1,000 350 Residuum 50 1,900 50,000 1,000 500 770 50 1,000	La Jolla	610	Alluvium	50	3,600	2,500	No
3,430 Alluvium 120 73,000 37,000 3,450 Residuum 40 22,000 10,000 3,400 Residuum 70 15,000 11,000 4,150 Residuum 70 23,000 16,000 1,030 Alluvium 50 1,200 900 1,030 Alluvium 50 4,100 2,800 1,780 Alluvium 50 4,100 2,800 1,780 Alluvium 50 4,800 4,800 17,110 Residuum 70 77,000 50,000 17,20 Alluvium 50 1,900 9,000 350 Residuum 50 1,900 9,000 17,20 1,000 5,000 1,000	itral Hydrologic Unit						
3,350 Alluvyum 40 22,000 10,000 3,400 Residuum 70 16,000 11,000 4,150 Residuum 70 23,000 16,000 220 Alluvium 50 1,200 900 1,030 Alluvium 50 4,100 2,800 1,780 Alluvium 50 4,800 4,800 1,780 Residuum 50 1,300 900 17,110 Residuum 70 77,000 50,000 1,290 Alluvium 50 1,400 1,000 350 Residuum 50 1,400 1,000 1770 Residuum 50 1,400 1,000	San Pasqual	3,430	Alluvium	120	73,000	37,000	153
3,400 Residuum 70 16,000 11,000 4,150 Alluvium 50 1,700 1,200 140 Alluvium 50 1,200 900 1,030 Alluvium 50 4,100 2,800 1,780 Alluvium 50 4,800 4,800 370 Residuum 50 1,300 900 17,110 Residuum 70 77,000 50,000 15,290 Alluvium 50 1,400 9,000 350 Residuum 50 1,400 1,000 170 Residuum 50 1,400 500	Lake Hodges	3,350	Alluvium Residuum	Ott	22,000	10,000	833
4,150 Residuum 70 23,000 16,000 220 Alluvium 50 1,700 1,200 140 Alluvium 50 4,100 2,800 1,780 Alluvium 50 4,800 4,800 1,780 Alluvium 50 4,800 4,800 17,110 Residuum 50 1,300 50,000 17,200 Alluvium 50 12,900 50,000 17,20 Residuum 50 1,400 1,000 170 Residuum 50 1,400 1,000	Felicita	3,400	Residuum	70	16,000	11,000	126
220 Alluvium 50 1,700 1,200 900 1,030 Alluvium 50 4,100 2,800 d 1,030 Alluvium 50 4,100 2,800 d 1,780 Alluvium 50 4,800 d 370 Residuum 50 1,300 900 17,110 Residuum 70 77,000 50,000 15,290 Alluvium 50 12,900 9,000 350 Residuum 50 1,000 1,000 170 Residuum 50 700 500	Green	4,150	Residuum	70	23,000	16,000	72
140 Alluvium 50 1,200 900 1,030 Alluvium 50 4,100 2,800 1,780 Alluvium 50 4,800 4a 370 Residuum 50 1,300 900 17,110 Residuum 70 77,000 50,000 1,290 Alluvium 50 12,900 9,000 350 Residuum 50 1,000 1,000 170 Residuum 50 1,000 500	Hidden	220	Alluvium	50	1,700	1,200	No data
1,030 Alluvium 50 4,100 2,800 1,780 Alluvium 50 6,900 4,800 370 Residuum 50 1,300 900 17,110 Residuum 70 77,000 50,000 1,290 Alluvium 50 12,900 9,000 350 Residuum 50 1,000 1,000 170 Residuum 50 1,000 500	Reed	140	Alluvium	50	1,200	900	18
1,780 Alluvium 50 6,900 4,800 de	East Guejito	1,030	Alluvium Residuum	50	001،4	2,800	No data
370 Residuum 50 1,300 900 17,110 Residuum 70 77,000 50,000 1,290 Alluvium 50 12,900 9,000 350 Residuum 50 1,000 1,000 170 Residuum 50 700 500	West Guejito	1,780	Alluvium Residuum	æ	006*9	4,800	No data
17,110 Residuum 70 77,000 50,000 1 1,290 Alluvium 50 12,900 9,000 350 Residuum 50 1,000 1,000	Highland	370	Res1duum	8	1,300	900	39
17,110 Residuum 70 77,000 50,000 12,900 9,000 1,290 Alluvium 50 12,900 9,000 350 Residuum 50 1,000 1,000 170 Residuum 50 700 500	and Hydrologic Unit						
1,290 Alluvium 50 12,900 9,000 350 Residuum 50 1,400 1,000 170 Residuum 50 700 500	Ramona	011,71	Res1duum	9,0	77,000	50,000	108
350 Residuum 50 1,400 1,000 170 Residuum 50 700 500	Pemo	1,290	Alluvium	50	12,900	9,000	29
170 Residuum 50 700 500	Lower Hatfleld	350	Residum	S.	1,400	1,000	29
	Upper Hatfleld	170	Residuum	50	700	200	13

GROUND WATER BASIN CHARACTERISTICS (continued)

Type: Area, in acres ; mater-b	Inland Hydrologic Unit (continued)	130 Res	920 Res	East Santa Teresa 770 Res	West Santa Teresa 190 Res	3,370 · Res
: : Maximum depth : Satimated average : Gross storage : Usable storage : to ground water acres : water-bearing : depth of material; capacity, in : capacity, in : th feet : naterial : in feet : acre-feet* : acre-feet** : Fall, 1957		Residuum 50	Residuum 50	Residuum 40	Residuum 50	Residuum 50
: Gross storage : Usable stora ; capacity, in : capacity, in : acre-feet* : acre-feet**		500	3,700	2,500	800	16,800
: Usable storege : capacity, in : acre-fee&***		360	2,600	1,700	500	11,700
* Maximum dep th		26	23	22	24	19

*Defined as the amount of water stored between historic high water level and base of water-bearing material.

**Defined as the upper portion of the gross storage capacity which may be utilized without so lowering the ground water levels to cause harmful impairment of the water quality or to imperil the economy of the use of ground water by excessive costs of pumping from the basin or by exclusion of the users from a supply therefrom.

Coastal Hydrologic Unit

The Coastal Hydrologic Unit is composed of a broad band of Eocene sediments which extend from the ocean eastward about 6 to 8 miles to the crystal-line rock area. The San Dieguito ground water basin is found in this unit, as shown on Plate 4.

San Dieguito Basin

The San Dieguito Basin, comprising an area of about 3,910 acres, underlies San Dieguito River Valley in the extreme west central portion of the Coastal Hydrologic Unit. The floor of San Dieguito Valley with an average elevation of 25 feet, is underlain by Recent alluvium and is extensively used for irrigated agriculture.

Geology. The valley is cut into the La Jolla formation of Eocene age, and backfilled to depths of as much as 200 feet with Recent alluvium. The alluvium in the San Dieguito Basin consists of stream-deposited gravel, sand, and clay. It is underlain and flanked by older Eocene formations, and is shown on Plate 6-A. The base of the alluvium is difficult to determine from the available well logs. The alluvium in the west end of the valley has a high clay content.

There are numerous minor faults and folds in the older formations surrounding the basin but none of these are known to affect the movement of ground water. The alluvium is apparently unaffected by faulting.

Occurrence of Ground Water. Ground water occurs in the alluvial fill of San Dieguito Basin and in the sands of the older formations that flank and underlie the alluvium. Alluvial fill constitutes the principal aquifer.

In cross-section, the alluvium of San Dieguito Basin is known to be shallow near the perimeter of the basin and to increase rapidly in thickness toward the center, as illustrated on Plate 6-A. Near the westerly extremity of the basin the alluvium at shallow depth contains considerable clay and silt. These fine materials serve to partially confine the underlying ground water. Wells drilled through these materials show artesian characteristics. In the eastern portion of the basin, however, unconfined water table conditions are found.

Movement of Ground Water. Ground water in the alluvium of San Dieguito Basin has generally moved westward toward the ocean. However, a landward gradient caused by heavy pumping, has existed in recent years. In the fall of 1957, a trough in the ground water surface was detected, located in Section 5, Township 14 South, Range 3 West, S.B.B. & M. West of this trough, sea water moves eastward into the basin as a result of the landward hydraulic gradient.

There is some exchange of water between the alluvium and the surrounding Eocene sediments. At times of high ground water levels, wells in the Eocene sediments yielded water of good quality and were widely used. In 1957, slowly percolating water high in dissolved solids was migrating from the Eocene sediments into the alluvium.

Replenishment and Depletion of Ground Water. Ground water in the alluvium of the San Dieguito Basin is replenished by percolation of direct precipitation, stream flow, and the unconsumed portion of water applied for irrigation and other uses. An additional source of replenishment is subsurface inflow from the older formations bordering the basin. Sea water intrusion constitutes an undesirable source of replenishment. Ground water in the adjacent older semi-permeable formations is replenished by rainfall penetration, stream percolation, and return flow of applied local and Colorado River water.

The ground water of the basin is depleted by pumped extractions, consumptive use, and at times of high water level, subsurface outflow.

Subsurface Outflow and Inflow. During the past, before extensive utilization of the ground water basin, when a seaward hydraulic gradient existed, subsurface outflow occurred through the buried mouth of the San Dieguito River. During the current period of overdraft, ground water levels and water quality indicate that some subsurface inflow enters the alluvial fill of the San Dieguito Basin from the ocean and from adjacent older formations.

Ground Water Storage Capacity and Specific Yield. Estimated weighted mean specific yield of the alluvium in the basin is 13.4 per cent. The specific yield of a sedimentary deposit is the ratio of the volume of water which it will yield by gravity, after being saturated, to its own volume. Historically utilized storage capacity in the basin was approximately 13,000 acre-feet, with the average elevation of the water table being about 12 feet below sea level. Storage capacity utilized below sea level was about 5,000 acre-feet. If the formation of a landward hydraulic gradient and accompanying sea-water intrusion is to be prevented, only about 8,000 acre-feet of storage can safely be utilized.

Yield of Wells. The average yield to domestic and irrigation wells is about 250 gallons per minute. The alluvium of San Dieguito Basin yields an average of 500 gallons per minute to irrigation wells with large pumps. The maximum known yield is about 600 gallons per minute.

Other Area

In the Coastal Hydrologic Unit, there is one other small area of alluvium from which ground water is extracted. This area, La Jolla Valley,

was not studied in detail due to the lack of significant ground water development; it is, however, delineated on Plate 4. Other pertinent information concerning this area is shown on Table B-2, B-3, and on Table 10, Volume I.

About 20,000 acres of the Coastal Hydrologic Unit are underlain by Eocene sediments from which minor amounts of ground water are extracted. It is reported that, two wells approximately 1-1/2 miles south of Lake Hodges flowed under artesian pressure at the time they were drilled. Water from these wells was of excellent mineral quality. Most of the wells, however, have low yield and produce poor quality water. Because of a lack of development, doubtful quality, meager quantity, and inadequate data, the Eocene sediments are not considered herein as a ground water basin. This area is shown on Plate 5.

Central Hydrologic Unit

The Central Hydrologic Unit is located between the Coastal Hydrologic Unit to the west and the Inland Hydrologic Unit to the east. It is underlain primarily by crystalline rock and to a lesser degree by alluvium in the stream channels and flood plains and by residuum on the heavily weathered slopes. Principal ground water basins within this unit include San Pasqual Basin, Lake Hodges Basin, and Felicita Basin. Locations of the basins in this unit are shown on Plate 4. Other portions of the Central Hydrologic Unit contain relatively small areas of shallow water-bearing materials. Water wells in such areas are usually shallow and have low yields. Some wells in these areas obtain water from fractures and broken zones within the crystalline rock.

San Pasqual Basin

This basin, with an areal extent of about 3,430 acres, lies in the central portion of the Central Hydrologic Unit and to the northeast of the San Dieguito Basin. The main basin averages about 390 feet in elevation and is drained soutwesterly by the San Dieguito River.

Geology. San Pasqual Valley is a comparatively long, narrow valley bounded and underlain by crystalline rock. Bedrock on the north is mostly tonalite with some metamorphic rocks, which rises gently in elevation, presenting slopes covered with a thin discontinuous layer of residuum. To the south, the valley wall consists of granodiorite and gabbro, and rises much more sharply and to a higher elevation than the north wall.

The valley fill consists of a maximum of at least 200 feet of course sand and gravel with some fine sand and clay as shown on Plate 6-B. Some of the available well logs show that there are cobblestones at depths

of over 100 feet, probably indicating an old stream channel. A few logs terminate in a layer of residuum, indicating a period of weathering before the valley was backfilled.

San Pasqual Valley is believed to be at least partly fault controlled. This hypothesis is supported by exploratory drilling at the narrows at the southwest end of the valley, which revealed subsurface fractures. Faulting is inferred by such at surface expressions as alignment of saddles and "V" shaped side canyons. The valley, 3,000 or more feet in width, makes a sharp turn to the south just before it enters the narrows where the width decreases to 1,000 feet. Here the walls rise steeply 200 feet on the west side and 700 feet on the east side.

Occurrence of Ground Water. Unconfined ground water occurs in the alluvium, which is the chief source of water to wells in the area. The residuum bounding the valley also contains unconfined ground water, but it generally yields less water to wells.

Movement of Ground Water. Ground water moves through the alluvium following the slope of the surface drainage toward Lake Hodges Basin as shown on Plate 7-A. There is no evidence suggesting any barriers to the movement of ground water in this basin, except for the constricting effect of the bedrock narrows at the western end.

Replenishment and Depletion of Ground Water. Ground water in San Pasqual Basin is replenished by percolation of both stream flow and direct precipitation. There is probably minor subsurface inflow from the fractured granitic rocks. There is usually some tributary stream flow, fed by springs in the hills, until early in the summer. These streams do not reach the main valley, but percolate into the alluvium in the side canyons. Ground water is depleted by pumped extractions, consumptive uses, and subsurface outflow through the narrows into Take Hodges Basin.

Subsurface Inflow and Outflow. Subsurface flow into San Pasqual Basin is probably negligible. The outflow, however, has been estimated by the slope-area method described in Chapter B-VII, to be about 600 acre-feet per year in 1956-57. A portion of the subsurface flow passing through the narrows at the lower end of the basin is being pumped by a battery of irrigation wells at the boundary between San Pasqual and Lake Hodges Basins.

Ground Water Storage Capacity and Specific Yield. Estimated weighted specific yield of the alluvium in the basin is 21 per cent. Maximum historically utilized storage in the basin was approximately 13,000 acre-feet and occurred in the fall of 1957. Usable storage capacity is estimated to be 37,000 acre-feet which would result in an average depth to water of about 75 feet.

Yield of Wells. Irrigation and domestic wells in the San Pasqual Basin yield an average of about 600 gallons per minute. Maximum known yield is about 1,700 gallons per minute. Most of the large irrigation wells yield on the order of 1,000 gallons per minute.

Lake Hodges Basin

Lake Hodges Basin, which comprises a surface area of about 3,350 acres, ranges in elevation from 190 feet at the foot of Hodges Dam to 450 feet south of the City of Escondido. This basin, about 1,100 acres of which is inundated by Hodges Reservoir when the lake is at spillway elevation, occupies the San Dieguito River channel and immediately adjacent areas of residuum. The location and areal extent of this basin is shown on Plate 4.

Geology. Lake Hodges Basin, drained southwesterly by the San Dieguito River, lies in a rather complex area of igneous and metamorphic rocks. These granitic and metamorphic rocks surround and underlie the

water-bearing materials. The elevation of the crystalline rocks bordering the western end of this long narrow basin varies from 700 to 900 feet. In the eastern end of the valley, because of the less resistant nature of the rock, the relief is less, or about 300 to 400 feet. Water-bearing formations within the basin may be divided into alluvium and deeply weathered residuum. The alluvium in Lake Hodges Basin consists of stream deposited gravel, sand, and clay up to at least 80 feet in thickness, as shown on Plate 6-B. A northward extending arm of residuum was included in this basin because of its hydraulic continuity with the alluvium. The residuum is typical of the deeply weathered material of the watershed, and is about 50 to 70 feet deep.

Occurrence of Ground Water. Ground water occurs in the alluvium and residuum. Yields of wells in the portion of the basin underlain by residuum are low, but due to the denser population this area contains a greater number of wells. In addition, Hodges Reservoir overlies a large portion of the alluvium. Free ground water conditions prevail in both the alluvium and the residuum. The water level maintained in Hodges Reservoir controls, to a large extent, the level of the water table in the remainder of the alluvial portion of Lake Hodges Basin.

Movement of Ground Water. Movement of ground water in the alluvium and residuum follows the slopes of the surface drainage as illustrated on Plate 7-D. Movement is, to some extent, controlled by the water level in Hodges Reservoir. When the lake is low the movement of ground water is toward the reservoir, but when the water level of the lake is raised rapidly, the movement of ground water may be reversed for short periods of time, until the dewatered storage space is filled.

Replenishment and Depletion of Ground Water. Lake Hodges Basin is replenished principally by surface and subsurface inflow from San Pasqual Basin

through the narrows. Replenishment of smaller magnitude also occurs by subsurface inflow from Felicita Basin, through the five small valleys which drain it. Percolation of precipitation and stream flow also contributes to the ground water of the basin. In times of heavy pumping, an eastward gradient could be developed which would allow water from Hodges Reservoir to percolate to the east. Ground water in the basin is depleted through pumped extractions and subsurface flow into Hodges Reservoir. Consumptive use also accounts for some of the depletion of the ground water.

Subsurface Inflow and Outflow. Subsurface inflow occurs from Felicita and San Pasqual Basins. Inflow from Felicita Basin has not been quantitatively determined, but an estimated 600 acre-feet of water a year flows into Lake Hodges Basin from San Pasqual Basin.

There is a very small amount of leakage under or around Hodges Dam, however, there is no other known subsurface outflow from Hodges Basin.

Ground Water Storage Capacity and Specific Yield. Estimated weighted specific yield of the residuum and alluvium of the basin is 16.5 per cent. Historically utilized storage in the basin is approximately 1,500 acre-feet.

Yield of Wells. Irrigation and domestic wells in the basin yield on an average of about 80 gallons per minute. The maximum known yield is about 800 gallons per minute. Most of the irrigation wells yield on the order of 95 to 100 gallons per minute.

Felicita Basin

Felicita Basin has an areal extent of about 3,400 acres and lies on the northern watershed boundary, as shown on Plate 4, at an average

elevation of about 680 feet. The basin drains southerly through five narrow channels into Lake Hodges Basin. The City of Escondido is situated in a portion of this basin.

Geology. The principle water-bearing formation in this basin is the deeply weathered residuum developed from tonalite. The residuum of the basin is weathered to depths of from 50 to 70 or more feet. Even though the residuum has a low specific yield, it does constitute a major source of ground water for irrigation and domestic use in the basin. Many of the wells have been drilled into the crystalline rock which underlies the basin and extract water from fractures and crevices in the rock.

The entire area is surrounded and underlain by tonalite, except on the northeastern corner where there is a body of granodiorite. In this area of granodiorite, the relief and elevation is considerably greater than the remainder of the basin because of the greater resistance of the granodiorite to weathering and erosion.

Occurrence of Ground Water. Unconfined ground water is extracted from the residuum of the basin, as well as from fractures in the crystalline rock which underlies the basin.

Movement of Ground Water. Ground water moves in a southerly direction from Felicita Basin into Lake Hodges Basin, as shown on Plate 7-D. The movement of water is through five narrow channels where water rises to the surface due to shallow depths to bedrock and flows throughout the winter months. It is reported that, before irrigation water was imported into the basin, the channels were dry except for runoff from storms.

Replenishment and Depletion of Ground Water. The principle sources of replenishment are percolation of direct precipitation and the unconsumed

portion of applied irrigation water. Use by phreatophytes, pumped extractions, and subsurface outflow account for the depletion of ground water.

Subsurface Inflow and Outflow. There is no subsurface flow into Felicita Basin from the adjoining areas.

Subsurface outflow does occur through the afore-mentioned five narrow channels into Lake Hodges Basin. Wells in the residuum and alluvium of the channels extract large amounts of water for irrigation and domestic use. These wells are the highest producers in the area and probably facilitate the subsurface flow by increasing the gradient of the ground water in their area of influence.

Ground Water Storage Capacity and Specific Yield. Estimated weighted specific yield of the residuum in the basin is 8 per cent. Historically utilized storage in the basin is approximately 9,000 acre-feet.

Yield of Wells. Irrigation and domestic wells in the basin yield an average of about 65 gallons per minute. Most of the irrigation wells yield on the order of 100 gallons per minute. The maximum known yield is about 300 gallons per minute.

Other Areas

There are six other areas of residuum and alluvium in this unit which are delineated as ground water basins and shown on Plate 4. These are Hidden, Reed, Green, Highland, and East and West Guejito Basins.

Because of their small size or lack of information, these basins are not discussed further in this report. Other infirmation concerning these areas are shown on Tables B-2, B-3, and on Table 10, Volume I.

Inland Hydrologic Unit

The Inland Hydrologic Unit is an area of deeply dissected old erosion surfaces which lie between the Central Hydrologic Unit and the eastern extreme of the San Dieguito River watershed. Residuum and minor amounts of alluvium comprise ground water basins in this unit. The Ramona Basin is the largest and most productive of these and is the only one discussed in this report.

The location of this basin is shown on Plate 4.

Ramona Basin

Ramona Basin includes an area of about 17,110 acres, stands at an average elevation of about 1,400 feet, and lies southeast of San Pasqual Basin in the western portion of the Inland Hydrologic Unit. Ramona Basin is drained northwesterly by Santa Maria Creek and Clevenger Canyon Creek into San Pasqual Valley.

Geology. Ramona Basin is bounded on the west by granodiorite and elsewhere by tonalites. The surface of the basin is underlain by weathered residuum which was formed on the underlying tonalites and granodiorite. A thin discontinuous layer of residuum covers the hills which surround the basin.

Most of Ramona Basin is drained by Santa Maria Creek and a small area is drained by Clevenger Canyon Creek. It is probable that Clevenger Canyon Creek at one time drained a much larger portion of the basin. Its canyon was probably eroded by a much larger stream than currently exists. It is also probable that the canyon between Ramona Basin and Pamo Valley once drained a part of Ramona Basin, even though it does not presently support a stream. From this evidence, it is believed that the entire plateau which is now Ramona Basin was tilted southwestward at some time in the geologic history of the region. Extending from Pamo Valley into Ramona Basin is the Temescal fault,

which is described in some detail in Chapter B-V, entitled "Structure". There are other smaller faults in this basin which are delineated on Plate 5.

Occurrence of Ground Water. Ground water is derived principally from wells tapping the deep residuum, however, there are a number of wells which extend down into the bedrock and extract water from fractures in the crystalline rock. Certain small areas of alluvium along the streams contribute minor amounts of ground water.

Movement of Ground Water. Ground water in Ramona Basin is unconfined and moves parallel to the slope of the ground surface. In the eastern portion of the basin, the Temescal fault, shown on Plate 6-B, controls the movement and gives rise to high ground water level conditions. Movement of ground water in the fall of 1957 is depicted by contours on Plate 7-C.

Replenishment and Depletion of Ground Water. Ground water is replenished by percolation of stream flow and direct precipitation as well as by the unconsumed portion of water applied for irrigation and other uses. Facilities are now under construction for importing Colorado River water to the basin. The ground water basin is depleted by pumped extractions, consumptive use and subsurface outflow.

Subsurface Inflow and Outflow. A limited amount of subsurface flow enters the basin through the alluvium of Hatfield and Goose Creeks in the east and northeastern portions of the basin, respectively. Outflow occurs through the thin alluvium of Santa Maria Creek in the western end of the basin. Some leakage may occur from the basin through the Temescal fault into Pamo Valley.

Ground Water Storage Capacity and Specific Yield. Estimated weighted specific yield of the residuum in the basin is eight per cent.

Historically utilized storage in the basin is approximately 20,000 acre-feet.

Yield of Wells. Wells in Ramona Basin yield an average of about 50 gallons per minute. Most of the irrigation wells yield on the order of 150 gallons per minute. The maximum known yield is about 250 gallons per minute.

Other Areas

There are eight other ground water basins in the Central Hydrologic Unit which are delineated on Plate 4. These areas are Upper and Lower Hatfield, Wash Hollow, Ballena, Pamo, Santa Ysabel, and East and West Santa Teresa Basins. Other pertinent hydrologic data for these basins are shown on Tables B-2, B-3 and on Table 10, Volume I.

CHAPTER B-VII. PROCEDURES FOR ESTIMATING GROUND WATER STORAGE AND SUBSURFACE FLOW

The purpose of this chapter is to explain the procedure used to estimate quantitative values of ground water storage and subsurface flow.

Ground Water Storage

Ground water is stored within the interstices of sediments and in cracks or fractures of solid rocks. The changes in ground water storage occurring over selected periods of study were estimated for the more important ground water basins within the watershed. With the exception of San Pasqual Basin, the available historic water level data were meager.

In general, the estimates required, first, a determination of the change in the volume of saturated sediments that occurred over a selected period of study, and second, an estimate of the percentage of this volume that contained extractable ground water. The first factor was obtained by computing the volume of sediments that lay between water levels that existed at the start and close of the study period, and the second factor, by evaluating, from available well logs, the average weighted specific yield of the sediments between water levels. Changes in the quantities of water stored were computed by multiplying the change in volume of saturated sediments by average weighted specific yield.

The State Division of Water Resources, predecessor agency to the Department of Water Resources, had previously conducted extensive field and laboratory investigations for the purpose of assigning specific yield values to various types of materials found in valley fill. These materials have been correlated with descriptive terms found in well logs. The procedures and conclusions are presented in Bulletin No. 45, "Geology and Ground Water Storage Capacity of Valley Fill, South Coastal Basin", Division

of Water Resources, 1934. Variations dictated by judgment and research, supplemented by values appearing in the "Hydrology Handbook", Manual of Engineering Practice No. 28, 1949, of the American Society of Civil Engineers, were adopted for use in this investigation.

The task of assigning specific yield values to the sediments indicated in well logs was simplified by dividing all basin sediments into nine general categories. These included clay, sandy clay, silt, fine sand, sand, gravel, tight gravel, boulder clay, and decomposed granite. Sand, gravel, and clay, constituting the bulk of the alluvium, were generally found to be well differentiated on the logs. The specific yield value used for residuum was that assigned in Table B-h under the classification decomposed granite.

Combinations of these materials, however, were frequently described by such unique terms as "ooze", "muck", "sea mud", etc. Materials so described were placed, based on judgment, into one of the above nine categories. Table B-h contains specific yield values assigned to the nine categories. In certain instances, these values were altered slightly whenever field observations indicated the advisability of change.

TABLE B-4
SPECIFIC YIELD OF WATER-BEARING MATERIALS

Material Classification	Description of Typical Malterial	: Assigned : Specific : Yield Value
Clay	Clay	.01
Sandy clay	Soil, sea mud, silty clay. Hard, fine, firm, and variegated decomposed granite	•05
Boulder clay	Clay and gravel, medium hard, soft, and medium fine decomposed granite	.07
Decomposed granite	An average figure to cover the range of typical decomposed granite	.08
Silt	Sandy soil. Coarse, medium, soft decomposed granite and decomposed granite with clay streaks	.10
Tight gravel	Cobbles, sand with clay streaks, packed sand with rocks. sandy mud, and alluvial decomposed granite	.14
Fine sand	Very fine sand and silty sand	•20
Gravel	Fine, medium, and coarse gravel	•22
Sand	Medium, coarse, very coarse sand, and gravelly sand	.30`

Subsurface Flow

Two methods are in common use to determine the magnitude of subsurface flow. These are the slope-area method and the rising water method. Since there is presently no rising water of appreciable quantity occurring in the San Dieguito River watershed, this method was not used. All estimates given herein were based on the slope-area method.

The slope-area method is derived from the commonly used form of Darcy's Law, Q=PAI, where Q equals subsurface flow in gallons per day passing

through the cross sectional area A in square feet, P is permeability in gallons per day per square foot, and I is the slope of the ground water surface at the corss section in feet per foot.

Field tests using pumping wells to determine permeability were conducted where possible. These data are summarized in Table B-5. Permeability was computed by the use of nonequilibrium methods, as outlined in the State Division of Water Resources "Report of Referee", dated June, 1952, in the action entitled California Water Service Company, a corporation, et al., plantiffs, vs. City of Compton, et al., defendants, Case No. 506806, in the Superior Court of the State of California in and for the County of Los Angeles. Slight variations in methods as suggested by Wenzel (1942) and Jacob and Cooper (1946) were used where necessary. In general, the recovery and the drawdown methods were used depending on field conditions. These methods depend on time-rate of recovery after pumping stops, and time-rate of drawdown in an observation well during pumping.

TABLE B-5

SUMMARY OF PERMEABILITY TESTS

: Storage : coeffi- : cient*	ì	.18	.01	1
Permea- bility, in gal./ day/ft.2	3,430	8,700	1,780	2,800
Trans-: Thick- missi-: ness bility,: of in gal./: aquifer, day/ft.: in feet	62	9	70	70
Trans- missi- bility, in gal./	.213,000	540,000	125,000	196,000
Test method	Recovery	Drawdown in ob- servation well	Drawdown in ob- servation well	Recovery in ob- servation well
Well use	Pumping and observation well	Pumping well Observation well	Pumping well Observation well	Pumping Observation well
Well :	138/1W- 6N1	13S/1W- GN1 13S/2W- 1J1	13S/3W-33C2 13S/3W-33C5	13S/3W-33C2 13S/3W-33C5
Basin and aquifer	San Pasqual alluvium	Sen Pasqual alluvium	San Dieguito alluvium	San Dieguito alluvium

Under water table conditions storage coefficient is essentially equal to * Defined as the quantity of water, in cubic feet, removed from one cubic foot of material when water level is lowered one foot. specific yield.

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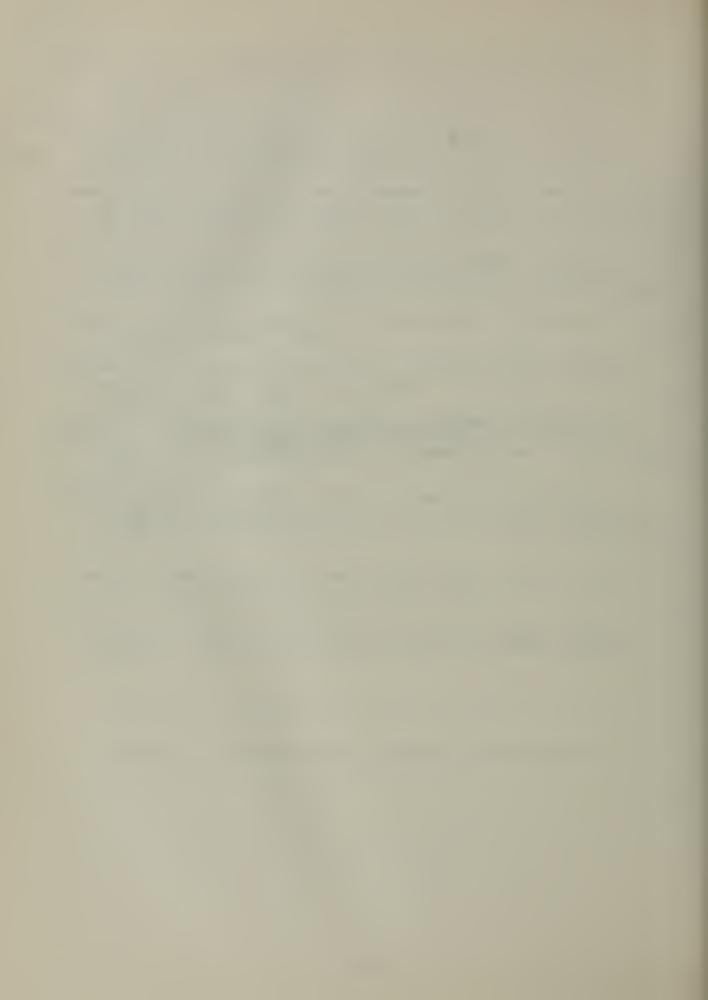
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^{*} Reports used in the preparation of Plate 5, "Areal Geology".

APPENDIX C

RECORDS OF MONTHLY PRECIPITATION AT SELECTED SITES
IN SAN DIEGUITO RIVER WATERSHED
FOR THE PERIOD 1936-37 THROUGH 1956-57



APPENDIX C

RECORDS OF MONTHLY PRECIPITATION AT SELECTED SITES
IN SAN DIEGUITO RIVER WATERSHED
FOR THE PERIOD 1936-37 THROUGH 1956-57

In Inches

Season :	Sutherland:	Pamo Dam	: San Pasqual	: Hodges
and month	Dam :		: Valley	: Dam
CLIC INCLOSE	Dour .	5200	• • • • • • • • • • • • • • • • • • • •	, ,
1936-37				
October	1.06	5.70	4.70	4.95
November	0.93	0.40	0.48	0.51
December	9.19	7.78	8.72	9.18
January	4.73	3.99	2.93	3.08
February	12.59	8.98	8.26	8.69
March	6.34	6.50	4.90	5.16
April	1.24	0.69	0.55	0.58
May	0.85	0.73	0.63	0.66
June	0	0	0	0.12
July	0.20	0.19	0.11	T
August	0.08 0.08	T O	0	0
September	0.00			
TOTALS	37.29 ^a	34.96 ^b	31.28 ^c	32.93
1937-38				
October	0	0	0	0
November	Ö	0.19	•09	0.10
December	2.59	1.90	2.00	2.11
January	2.67	1.66	1.27	1.34
February	6.59	6.10	5.39	5.67
March	11.80	9.40	6.64	6.99
April	1.65	0.92	0.82	0.86
May	0.89	0.41	0.32	0.34
June	0	0.06	0.10	0.11
July	0.10	T	0	0
August	0.48	T	0.02	0.03
September	0	0	0	0
TOTALS	26.77ª	20.64 ^b	16.67°	17.55

RECORDS OF MONTHLY PRECIPITATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57 (continued)

In Inches

5045011	: Sutherland :	Pamo Dam site	: San Pasqual :	Hodges Dam
and month	: Dam :	site	: Valley :	Dam
1938-39				
October	0.75	0.08	4.72	4.97
November	0.10	0.08	0.07	0.08
December	8.09	6.58	5.06	5.33
January	4.86	3.46	3.14	3.31
February	3.86	2.55	1.60	1.68
March	4.18	2.20	1.70	1.79
April	1.03	0.79	0.81	0.85
May	0.21	0.20	0	0.05
June	0	0	0	0
July	0	0	0	0
August	0	T	0	0
September	6.73	3.38	3.18	3.35
_				
TOTALS	29.81 ^a	19.32 ^b	20.28 ^c	21.41
1939-40				
October	0.81	0.41	0.48	0.51
November	0.97	0.66	0.29	0.29
December	1.36	0.54	0.49	0.52
January	6.47	5.09	4.56	4.80
February	6.35	5.47	4.99	5.25
March	0.61	0.30	0.30	0.32
April	4.08	4.47	2.99	3.15
May	0	T	0	0
June	0	Ť	0	0
July	0	0	0	0
August	0	0	0	0
September	0	0.12	0.04	0.04
	9		-1 -1 C	-1 00
TOTALS	20.65 ^a	17.06 ^b	14.14 ^c	14.88
1940-41				
October	2,15	1.94	1.11	1.17
November	1.52	0.70	0.36	0.38
December	10.04	9.16	5·33	5.60
January	2.66	2.19	1.84	1.94
February	6.01	5.79	4.72	4.96
March	10.29	7.22	6.40	6.74
April	10.92	5.13	4.96	5.22
May	2.00	0.82	0.76	0.80
June	0.20	0.13	0	0
July	0.10	0.10	0	0.02
August	0.08	0.09	0	0
September	0.62	0.18	0.14	0.15
TOTALS	45.59 ^a	33.45 ^b	25.62°	26.98

RECORDS OF MONTHLY PRECIPITATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57 (continued)

In Inches

Concon	: Sutherland :	Pamo Dam	: San Pasqual :	Hodges
Season and month	: Sutherland :	site	: Valley :	Dam
	· Dan ·	5100	, taring,	2000
1941-42			0.1	
October	4.04	2.65	2.84	2.99
November	1.77	2.68	2.45	2.57
December	4.01	5.10	5.98	6.29 0.78
January	1.58	0.76	0.74 2.05	2.16
February March	3•73 2.84	3.38 1.84	1.45	1.53
April	3.10	3.03	2.38	2.51
May	0.12	0	0.08	0.08
June	0	0	0	0
July	0	0	0	0
August	0	0.32	0.11	0.12
September	0	0	0	0
TOTALS	21.19 ^a	19.76 ^b	18.08°	19.03
a olio lia				
1942-43 October	0.76	0.34	0.1414	0.46
November	0.70	0.34	0.24	0.25
December	2.08	1.79	1.88	1.98
January	8.09	7.54	6.88	7.24
February	2.88	2.00	1.54	1.62
March	4.48	2.69	3.03	3.20
April	5.24	2.05	1.73	1.82
May	0	0.08	0.03	0.03
June	0.59	0.08	0.12	0.13
July	0	0	0	0
August	0	0	0	0
September	0.02	T	0.02	0.02
TOTALS	24.84ª	16.84 ^b	15.91°	16.75
1943-44				
October	0.82	0.35	0.25	0.26
November	0.04	0.03	0.03	0.03
December	6.11	8.01	7.37	7.76
January	2.55	1.70	0.99	1.04
February	9.70	4.78	4.07	4.28
March	2.67	1.64	1.27	1.34
April	1.43	1.00	0.85	0.89
May	0.54	0.41	0.11	0.12
June	0.28	0.56	0.41	0.43
July	0	0	0	0
August	0	0	0 0.04	0 05
September	0	T	0.04	0.05
TOTALS	24.14 ^a	18.48b	15.39 ^c	16.20

RECORDS OF MONTHLY PRECIPITATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57 (continued)

In Inches

Season and month	: Sutherland : : Dam :	Pamo Dam site	: San Pasqual : : Valley :	Hodges Dam
and month	· Dani ·	BICE	· variey .	Dalii
1944-45				
October	0	0.28	0	0
November	7.87	4.78	5.06	5.33
December	2.01	1.45	1.39	1.46
January	0.69	0.29	0.06	0.06
February	3.76	2.48	2.35	2.47
March	6.85	5.40	4.95	5.21
April	0.40	0.30	0.09	0.10
May	0.22	0.04	0	0
June Talan	0.29	0.15	0.08	0.08
July	0 2.08	0 2.48	0 1.86	0 1.96
August September	0.07	T T	0.09	0.10
peh remnet.	0.07		0.09	0.10
TOTALS	24.24ª	17.65 ^b	15.93°	16.77
1945-46				
October	0	T	0	0
November	0.68	0.50	0.37	0.39
December	8.10	5.95	4.74	4.99
January	1.77	0.73	0.95	1.00
February	1.70	1.48	1.00	1.06
March	4.10	3.48	2.90	3.05
April	0.77	0.85	0.44	0.46
May	0.02	0.22	0.08	0.08
June	0	0	0	0
July	0	0	0	0
August September	0.11	0	0	0
pehcemper	0.11			
TOTALS	17.25ª	13.21b	10.48c	11.03
1946-47				
October	1.84	1.85	1.12	1.06
November	4.62	5 . 38	3.77	3.92
December	2.62	1.85	1.21	1.62
January	1.22	0.52	0.29	0.30
February	1.07	0.65	0.39	0.59
March	1.75	2.94	2.77	2.53
April	1.06	0.52	0.68	0.42
May	0.10	0	0.05	0.09
June	0	0	0	0
July August	0 0.20	0	0	0
September		0.10	0.11	0.07
pohocimer	0.32		0.77	
TOTALS	14.80 ^a	13.81 ^b	10.39	10.60

In Inches

and month Dam Site Valley Dam	Season	: Sutherland	: Pamo Dam	: San Pasqual :	Hodges
1947-48				_	
TOTALS 15.148 9.10b 8.32 9.09 1948-49 October 2.07 1.34 1.19 0.91 November 0 0 0.05 0 December 5.24 3.17 2.78 2.69 January 7.46 5.23 4.89 4.97 February 3.97 2.14 1.90 1.96 March 2.47 1.75 1.10 1.56 April 0.16 0.15 0.53 0.02 May 1.50 1.04 0.58 0.91 June 0 0 0 0 0 July 0 0 0 0 0 September 0 0 0 0 TOTALS 22.87a 14.82b 13.02 13.02 1949-50 October 0.68 0.20 0.16 0.06 November 2.18 1.55 1.21 1.11 December 1.63 1.45 1.25 1.60 January 5.09 4.32 3.22 4.38 February 3.14 1.72 1.52 1.68 March 2.29 1.40 1.29 1.08 April 0.85 0.42 0.40 0.43 May 0.87 0.24 0.24 0.09 June 0.04 0.01 0 0 July 0.00 0.00 August 0.00 0.00 October 0.68 0.20 0.16 0.06 November 0.68 0.20 0.16 0.06	1947-48 October November December January February March April May June July August	0.72 0.73 4.37 0.26 3.13 3.78 1.07 0.04 1.04 0	0.65 0.62 2.36 0.03 1.49 2.35 0.85 0	0.52 0.56 2.49 0.03 1.56 2.12 0.59 0	0.41 1.21 2.38 0 1.33 2.66 0.77 0 0.33
October 2.07 1.34 1.19 0.91 November 0 0 0 0.05 0 December 5.24 3.17 2.78 2.69 January 7.46 5.23 4.89 4.97 February 3.97 2.14 1.90 1.96 March 2.47 1.75 1.10 1.56 April 0.16 0.15 0.53 0.02 May 1.50 1.04 0.58 0.91 June 0 0 0 0 0 July 0 0 0 0 0 August 0 T 0 0 September 0.68 0.20 0.16 0.06 November 2.18 1.55 1.21 1.11 December 1.63 1.45 1.25 1.60 January 5.09 4.32 3.22 4.38 February 3.14 1.72 1.52 1.88 March 2.29 1.40 1.29 1.08 April 0.85 0.42 0.40 0.43 May 0.87 0.24 0.24 0.09 June 0.00 0 0 July 0.00 0 0.00 April 0.85 0.42 0.40 0.43 May 0.87 0.24 0.24 0.09 June 0.04 0.01 0 0 July 0 0 0.01 0 0 July 0 0 0.01 0 0.02 August 0 0 0 0 0 0.05	ребоещоет				
October 2.07 1.34 1.19 0.91 November 0 0 0.05 0 December 5.24 3.17 2.78 2.69 January 7.46 5.23 4.89 4.97 February 3.97 2.14 1.90 1.96 March 2.47 1.75 1.10 1.56 April 0.16 0.15 0.53 0.02 May 1.50 1.04 0.58 0.91 June 0 0 0 0 July 0 0 0 0 August 0 T 0 0 September 0 0 0 0 TOTALS 22.87a 14.82b 13.02 13.02 1949-50 0 0 0 0 0 October 0.68 0.20 0.16 0.06 November 2.18 1.55 1.21 1.11 </th <th>TOTALS</th> <th>15.14^a</th> <th>9.10^b</th> <th>8.32</th> <th>9.09</th>	TOTALS	15.14 ^a	9.10 ^b	8.32	9.09
1949-50 October 0.68 0.20 0.16 0.06 November 2.18 1.55 1.21 1.11 December 1.63 1.45 1.25 1.60 January 5.09 4.32 3.22 4.38 February 3.14 1.72 1.52 1.88 March 2.29 1.40 1.29 1.08 April 0.85 0.42 0.40 0.43 May 0.87 0.24 0.24 0.09 June 0.04 0.01 0 0 July 0 0.01 0 0 September 0.22 0.14 0.03 0.05	October November December January February March April May June July August	0 5.24 7.46 3.97 2.47 0.16 1.50 0	0 3.17 5.23 2.14 1.75 0.15 1.04 0	0.05 2.78 4.89 1.90 1.10 0.53 0.58 0	0 2.69 4.97 1.96 1.56 0.02 0.91 0
October 0.68 0.20 0.16 0.06 November 2.18 1.55 1.21 1.11 December 1.63 1.45 1.25 1.60 January 5.09 4.32 3.22 4.38 February 3.14 1.72 1.52 1.88 March 2.29 1.40 1.29 1.08 April 0.85 0.42 0.40 0.43 May 0.87 0.24 0.24 0.09 June 0.04 0.01 0 0 July 0 0.01 0 0 August 0 0 0 0 September 0.22 0.14 0.03 0.05	TOTALS	22.87ª	14.82 ^b	13.02	13.02
TOTALS 16.99 ^a 11.46 ^b 9.32 10.70	October November December January February March April May June July August September	2.18 1.63 5.09 3.14 2.29 0.85 0.87 0.04 0	1.55 1.45 4.32 1.72 1.40 0.42 0.24 0.01 0.01	1.21 1.25 3.22 1.52 1.29 0.40 0.24 0	1.11 1.60 4.38 1.88 1.08 0.43 0.09 0

In Inches

Season	: Sutherland :		: San Pasqual :	Hodges
and month	: Dam :	site	: Valley :	Dam
1950-51				
October	0	0.01	0	0
November	2.28	1.85	1.71	2.11
December	0.18	0.03	0.01	0.10
January	4.12	3.39	2.85	3.05
February	2.45	1.02	0.97	1.28
March	1.36	0.66	0.56	0.41
April	3.91	2.55	1.41	2.17
May	0.50	0.02	1.14	0
June	0	0	0	0
July	0	0.29	0 0.80	0.08 0.64
August	2.17	0.73		0.18
September	0.14	0.24	0.11	0.10
TOTALS	17.11 ^a	10.79 ^b	9.56	10.02
1951-52				
October	1.79	1.08	0.92	1.10
November	1.74	1.73	1.46	1.01
December	8.29	7.02	1.78	5.85
January	7.23	6.10	8.60	6.25
February	2.37	0.23	0.19	1.22
March	8.12	6.05	6.46	4.84
April May	3.02 0	1.90	1.83 0	2.01 0
June	0.19	0.03	0	0.02
July	0	T	ŏ	0
August	Ö	ō	Ö	Ō
September	0.19	0.10	0	0.05
_				
TOTALS	32.94ª	24.24 ^b	21.34	22.35
1952-53				
October	0	0	0	0
November	4.59	3.37	2.13	2.37
December	4.21	3.15	2.50	2.74
January	2.38	1.75	2.27 0.64	1.46
February March	1.95 2.24	0.80 1.53	1.39	1.01
April	1.70	1.43	1.08	1.44
May	1.25	0.35	0.12	0.17
June	0.08	0.04	0.08	0.12
July	0	0	0	0
August	0	0	0.03	0
September	0	0	0	0
TOTALS	18.40 ^a	12.42 ^b	10.24	10.44

In Inches

	A Clark horal and	Down Down	Con Docume?	Hodges
Season	: Sutherland :	Pamo Dam : site :		Hodges Dam
and month	: Dam :	site :	Valley :	Dani
1953-54				
October	0.25 ^a	0.09	0.18	0.08
November	1.45ª	1.30	1.16	1.09
December	0.56ª	0.30	0.22	0.17
January	6.39ª	5.02	4.36	4.29
February	2.15 ^a	2.84	2.05	2.31
March	8.63	5.35	4.81	5.11
April	0.40	0.28	0.04	0.25
May	0.05	0.10	0.13	0
June	0.21	0.16	0.05	0.06
July	0.60	0	0	0.05
August	0.08	Ö	Ō	0
September	0	Ö	0.08	0
DCD 0CMDC1				
TOTALS	20.17	15.44 ^b	13.08	13.35
	· ·			
1954-55				
October	0	0	0.01	0
November	0.99	1.02	1.01	0.98
December	1.14	1.13	0.64	0.89
January	7.17	4.52	3.49	4.47
February	2.61	1.00	0.88	1.32
March	1.04	0.70	1.11	0.65
April	1.59	0.62	0.47	1.48
May	2.14	1.65	1.72	1.43
June	0	0	0	0
July	0.13	0	0	0
August	0.17	0.08	0.08	0.02
September	0	0	0	0
MOTAT C	16.98	10.72 ^b	9.41	11.24
TOTALS	10.90	10.72	9•4±	TT 0 C T
1955-56				
October	0	0	0	0
November	1.66	1.44	1.10	1.37
December	2.55	1.00	0.82	0.69
January	7.36	4.75	3.21	4.21
February	1.72	0.68	0.50	0.44
March	0.35	0	0.01	0.02
April	2.43	1.54	1.18	1.44
May	0.54	0.20	0.26	0.24
June	0	0	0	0
July	0.04	0	0	0
August	0	0	0	0
September	0	0	0	0
		- C- b		0.1.2
TOTALS	16.65	9.61 ^b	7.08	8.41

In Inches

	a : site	: Valley	: Dam
1956-57 October Octobe	0.22 0.4 0.62 8.48 55 0.65 79 1.56 36 1.28 59 1.53 70 0	0.19 NR 0.58 6.67 0.62 1.14 1.10 1.36 0.40 0	0.22 0 0.58 7.68 0.82 1.11 1.17 1.76 0.65 0

a. Estimated from measured values of precipitation at El Capitan Dam.

b. Estimated from measured values of precipitation at U. S. Weather Bureau station at Escondido.

c. Estimated from measured values of precipitation at Hodges Dam.

T Trace, an amount too small to measure.

NR No record.

APPENDIX D

ESTIMATES OF MONTHLY RUNOFF FROM SELECTED AREAS IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1914-15 THROUGH 1956-57



APPENDIX D

ESTIMATES OF MONTHLY RUNOFF FROM SELECTED AREAS IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1914-15 THROUGH 1956-57

	•	: . D. t		:	Delega	: Between
	•	: Between	Datas	To done on	Between	:San Pasqual
	Λλ	:Sutherland		: Between :	Pamo Dam	: Dam site
	: Above		Pamo and	:Sutherland :	site and	: and
Season	:Sutherland		San Pasqual		Hodges	: Hodges
and month	: Dam ^a	: Dam site	: Dam sitesb	:Hodges Dam ^c :	Dam ^C	: Dam
1914-15						
October	50	0	0	0	0	0
November	80	50	20	0	0	0
December	270	130	100	0	0	0
January	2,230	2,090	4,010	4,580	3 050	•
February	8,660	5,740	8,800	14,800	3,050 9,810	730 3,400
March	4,910	2,590	3,460	2,410	7.6	
April	2,640	2,210	1,760	3,970	570 2,530	150 670
May	9,220	4,380	5,620	10,860	5,340	1,410
June	2,050	750	800	10,000	0,340	0
July	610	350	220	0	0	0
August	230	340	100	0	0	0
September	180	50	70	0	0	0
DCP 0CMDCI						
TOTALS	31,130	18,680	24,960	36,620	21,300	6,360
1915-16						
October	130	40	80	0	0	0
November	220	140	170	0	0	0
December	440	310	320	0	. 0	0
January	66,400	37,600	87,870	189,970	145,520	42,480
February	11,600	8,200	14,660	13,160	4, 960	1,450
March	7,810	3,390	7,920	8,440	5,050	1,500
April	4,090	1,970	3,640	2,570	600	200
May	2,140	1,200	1,760	1,100	0	0
June	1,140	540	870	0	0	0
July	590	330	420	0	0	0
August	270	380	240	0	0	0
September	420	90	260	0	0	0
TOTALS	95,250	54,190	118,210	215,240	156,130	45,630
	77,-74	2.,-20			- 709 - 30	17,000

			In Acre-reco			Į.
Season and month	: : Above :Sutherland : Dam ^a		: : Between : Pamo and :San Pasqual : Dam sites ^b	Between : Sutherland : Dam and : Hodges Dam ^C	Between Pamo Dam site and Hodges Dam ^C	: Between :San Pasqual : Dam site : and : Hodges : Dam
1916-17						
October November December January February March April May June July August September	480 380 700 1,880 3,460 2,510 1,580 1,320 770 340 170 130	560 380 1,160 1,660 3,760 1,130 1,180 700 20 10 0	220 170 550 1,770 2,420 1,280 890 550 230 80 50	640 30 2,100 5,710 4,830 2,090 1,880 620 500 0	640 30 270 2,800 1,070 960 700 270 490 0	620 0 230 70 30 20 20 10 10 0
TOTALS	13,720	10,620	8,260	18,400	7,230	1,010
1917-18 October November December January February March April May June July August September TOTALS	70 160 130 220 350 3,990 990 740 420 100 100 90	80 140 180 520 550 3,820 250 0 0 0	50 140 120 260 360 6,600 770 450 210 60 50 50	0 0 0 240 0 17,100 520 30 0 0 0	0 0 0 240 0 11,430 440 20 0 0 0	0 0 0 200 0 6,410 340 10 0 0
October November December January February March April May June July August September TOTALS	130 330 560 360 930 1,440 640 310 60 10 10 30	40 120 180 120 30 250 200 130 0 0	20 40 60 40 170 340 80 30 10 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0

	•			•	•	: Between
Season and month	Above Sutherland Dam ^a		mo and Pasqual	: Between :Sutherland : Dam and :Hodges Dam	: Hodges	:San Pasqual : Dam site
1919-20	(
October November December January February March April May June July August September	60 260 440 250 1,370 5,040 2,980 1,370 380 90 250 30	0 0 30 970 2,150 1,790 360 170 10	0 30 40 30 210 1,870 640 200 60 10 20	10 10 30 20 860 1,900 0 0	10 10 30 20 780 480 0 0	0 0 0 750 0 0 0
TOTALS	12,520	5,480	3,110	2,830	1,330	750
1920-21 October November December January February March April May June July August September TOTALS	100 170 230 430 410 650 320 600 240 20 0	0 0 60 220 120 360 40 190 0 0 0	0 30 50 100 100 160 70 130 50 0	0 30 30 110 60 390 50 0 0 0	0 30 30 110 60 390 50 0 0 0	0 0 70 30 370 30 0 0 0
1921-22 October November December January February March April May June July August September TOTALS	70 50 11,400 5,530 10,400 9,280 5,370 2,940 1,310 500 210 100	0 0 8,900 3,880 6,700 6,020 3,730 2,190 670 320 80 50	10 10 9,010 3,710 7,950 6,950 3,560 1,650 540 190 60 30 33,670	0 0 21,570 5,160 17,040 15,030 5,230 1,660 0 180 0 180	0 0 13,580 1,140 7,470 7,550 1,500 0 180 0 180 31,600	0 0 2,940 250 1,620 1,630 320 0 0 180 0

	:	2		:	D-4	: Between
		Between :	Between	: Between :	Between Pamo Dam	:San Pasqual : Dam site
			Pamo and	:Sutherland :	site and	: and
Season	:Sutherland:		San Pasqual	: Dam and :	Hodges	: Hodges
and month			: Dam sitesb	:Hodges Damc:	Damc	: Dam
1922-23	120	60	40	130	30	30
October November	130 320	160	110	180	50 50	40
December	1,380	680	670	980	260	230
January	820	400	350	40	10	10
February	2,420	1,190	1,460	2,340	630	550
March	1,650	810	850	1,350	360	320
April	1,610	790	820	580	160	140
May	720	360	310	40	10	10
June	330	160	120	120	30	30
July	90	50	40	150	40	40
August	50	30	20	130	30	30
September	40	20,	10		20	10
TOTALS	9,560	4,710 ^c	4,800	6,060	1,630	1,440
1923-24						
October	70	50	40	0	0	0
November	120	70	90	30	30	0
December	230	140	160	60	60	20
January	260	160	180	70	70	30
February	140	80	100	70	70	40
March	860	520	600	1,030	980	960
April	790	480	600	320	290	270
May	230 40	130 20	160 40	90 50	90 50	80°' 40
June July	0	0	0	50 180	180	180
August	Ö	0	0	110	110	110
September	Ö	ő	Ŏ	0	0	0
TOTALS	2,740	1,650°	1,970	2,010	1,930	1,730
1924-25	29140	1,0,0	±,010	2,020	Ξ,)) Ο	±9100
October	10	0	0	0	0	0
November	70	30	30	ő	0	Ö
December	610	220	250	180	180	140
January	320	120	110	50	50	10
February	260	90	100	60	60	30
March	390	140	160	50	50	30
April	1,100	400	540	510	210	190
May	360	130	160	40	40	30
June Tul	340	120	140	0	0	0
July	10 0	0	0	0	0	0
August September	0	0	0	0	0	0
TOTALS	3,470	1,250°	1,490	590	590	430

1	:		•	:		: Between
	:	Between		: :	Between	:San Pasqual
		Sutherland		: Between :	Pamo Dam	: Dam site
_	: Above :		: Pamo and	:Sutherland :		: and
. Season	:Sutherland:		:San Pasqual	: Dam and :	Hodges	: Hodges
and month	: Dam ^a :	Dam site ·	: Dam sitesb	:Hodges Dam ^C :	Dam ^C	: Dam
1925-26						
October	160	100	60	0	0	0
November	180	110	60	0	0	0
December	200	120	80	0	0	0
January	170	100	60	0	0	0
February	1,190	710	420	180	120	90
March	400	240	150	0	0	. 0
April	11,310	6,790	8,760	16,160	8,910	2,400
May	1,290	770	470	0	0	0
June	360	220	120	0	0	0
July	70	40	30	0	0	0
August	10	10	0	0	0	0
September	0	0	0	0	0	0
TOTALS	15,340	9,210 ^c	10,210	16,340	9,030	2,490
1926-27						
October	20	20	10	0	0	0
November	110	80	50	Ō	0	0
December	2,070	1,530	1,630	Ō	Ō	0
January	870	640	530	Ō	0	0
February	30,800	22,730	36,860	94,100	64,000	18,500
March	8,200	6,050	9,280	6,920	1,000	300
April	3,680	2,720	3,340	4,460	740	150
May	2,050	1,510	1,620	1,670	160	50
June	1,140	840	770	0	0	0
July	250	190	150	0	0	0
August	150	110	90	0	0	0
September	210	160	120	0	0	0
TOTALS	49,550	36,580°	54,450	107,150	65,900	19,000
1927-28						
October	180	120	130	0	0	0
November	210	130	150	40	40	30
December	570	340	520	30	20	10
January	510	300	450	1,010	490	330
February	780	470	770	2,680	1,250	850
March	620	370	560	880	´38o	260
April	400	240	340	20	20	10
May	280	170	170	80	80	60
June	70	40	40	0	0	0
July	Ö	0	0	0	0	0
August	Ō	0	0	0	0	0
September	0	0	0	0	0	0
_	2 (00	0.7900	2 720	4,740	2,280	1,550
TOTALS	3,620	2,180°	3,130	4, [40	2,200	1,770

	:	_	:	:	Dadasasas	: Between
		Between	Deteran	: Between :	Between Pamo Dam	:San Pasqual : Dam site
		Sutherland	: Between : Pamo and	: Sutherland :	site and	: and
Season	: Above : Sutherland:	Dam and Pamo	:San Pasqual	: Dam and :	Hodges	: Hodges
			: Dam sitesb	:Hodges Dam ^C :	Damc	: Dam
and month	: Dam :	Dan Site	. Dall Stees	.Houges Dam .	Dan	• Donn
1928-29						
October	0	0	0	0	0	0
November	200	130	160	0	0	0
December	190	110	150	250	100	20
January	430	260	380	250	100	20
February	800	480	800	830 650	330 260	50 40
March	1,080	640	1,150	650	420	70
April	1,540	<i>9</i> 20 260	1,720 380	1,050 150	60	10
May June	430 160	100	130	150	0	0
• • • • • • • • • • • • • • • • • • • •	10	100	130	0	0	0
July August	0	0	0	0	0	ŏ
September	50	20	20	0	Ö	ŏ
_					-	
TOTALS	4,890	2,930 ^c	4,890	3,180	1,270	210
1929-30						
October	10	0	0	0	0	0
November	30	10	10	0	0	0
December	30	10	10	10	10	0
January	1,020	620	780	430	300	80
February	560	340	400	510	510	130
March	1,940	1,160	1,590	1,420	290	70
April	1,030	620	800	460	120	30
May	2,650	1,600	2,330	4,260	1,130	280
June	560	340	390	0	0	0
July	140	90	90	0	0	0
August	30	20	20	0	0	0
September	10	0	0	0	0	0
TOTALS	8,010	4,810 ^c	6,420	7,090	2,360	590
	,			., .	, -	
1930-31	(0	l.o		_	•	_
October	60	40	30	0	0	0
November	280	160	120	0	0	0
December	180 280	120	70	180	180	140
January		170 830	130	900	430	330
February March	1,390	210	770 150	900	430	0
April	350 280	170	130	120	0	0
May	250	150	100	130	120	Ö
June	20	10	0	0	0	Ö
July	0	0	0	0	0	0
August	0	0	0	0	0	Ö
September	0	0	0	0	0	ŏ
_						-
TOTALS	3,090	1,860°	1,500	1,330	730	470

Season and month	: Above : :Sutherland:	Pamo :	Between Pamo and San Pasqual Dam sites ^b	: Between : Sutherland : Dam and : Hodges Dam ^c :	Between Pamo Dam site and Hodges Dam ^C	: Between :San Pasqual : Dam site : and : Hodges : Dam
1931-32 October November December January February March April May June July August September	10 100 1,350 1,150 21,280 3,980 1,600 980 550 200 50	10 50 720 610 11,370 2,130 860 520 290 110 30 20	0 30 580 460 17,670 2,490 730 390 210 60 20	0 0 3,250 540 28,560 6,060 930 710 110 0	0 0 3,120 430 14,070 3,930 90 710 110 0	0 0 2,960 390 500 200 0 0 0
TOTALS 1932-33 October November December January February March April May June July August September TOTALS	31,280 100 60 350 2,000 1,560 880 700 1,310 490 110 30 10 7,600	16,720° 70 50 260 1,480 1,160 650 520 970 360 80 20 10 5,630°	22,640 60 40 240 1,730 1,310 670 530 1,070 350 60 10 0 6,070	40,160 50 10 1,240 3,830 2,220 0 470 1,260 0 0 9,080	22,460 50 10 1,240 1,830 440 0 0 330 0 0 3,900	4,050 0 0 350 520 130 0 100 0 0 1,100
1933-34 October November December January February March April May June July August September TOTALS	10 30 200 310 250 260 120 0 0	10 20 120 180 150 150 70 0 0 0	0 10 100 130 110 110 50 0 0	0 10 390 250 480 160 0 0 0	0 10 390 250 480 160 0 0 0	0 0 350 210 450 140 0 0 0

	: :	-	:	:	D-1	: Between
		Between Sutherland	: Between	: Between :	Between Pamo Dam	:San Pasqual : Dam site
	: Above :	Dam and	: Pamo and	: Sutherland :	site and	: and
Season	:Sutherland:	Pamo	:San Pasqual	: Dam and :	Hodges	: Hodges -
and month		Dam site		:Hodges Damc:	Damc	: Dam
						
1934-35	0	0	0	220	220	200
October November	0 70	60	30	250	250	220
December	290	230	130	750	750	710
January	820	660	420	290	260	220
February	920	740	480	680	580	550
March	1,400	1,120	850	0	0	0
April	760	610	400	0	0	0
May	330	260	140	0	0	0
June	50	40	10	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
TOTALS	4,640	3,720 ^c	2,460	2,190	2,060	1,900
1935-36					_	
October	0	0	0	0	0	0
November	0	0	0	50	50	20
December	20 100	10 60	10 60	100 80	100 80	60 40
January February	2,610	1,690	2,080	3,010	1,300	1,090
March	930	600	2,000 540	410	1,300	1,090
April	1,970	1,300	1,410	1,040	440	ő
May	520	330	270	0	0	Ō
June	60	40	20	0	0	0
July	100	60	60	0	0	0
August	20	10	0	0	0	0
September	0	10	0	0	0	0
TOTALS	6,330	4,110 ^c	4,450	4,690	2,140	1,210
1936-37						
October	0	0	0	1,070	1,070	1,050
November	30	30	20	40	40	10
December	2,010	1,620	2,320	3,880	2,040	1,020
January	3,610	2,920	4,440	6,560	1,390	250
February	22,350	18,080	29,830	49,770	29,700	5,310
March	10,880	8,800	14,860	36,630	27,830	4,950
April	5,010	4,050	6,590	13,030	8,980	2,160
May	2,220	1,790	2,550	2,800	1,010	240
June July	980 3.50	800 280	1,020 140	760	310	110
August	350 90	200 80	50	0	0	0
September	40	30	20	0	0	0
_						
TOTALS	47,570	38,480	61,840	114,540	72,370	15,100

			1102 0 2 000			
Season and month	: Sove : Sutherland:	Pamo	Between Pamo and San Pasqual Dam sites	Between: Sutherland: Dam and: Hodges Dam ^C :	Between Pamo Dam site and Hodges Dam ^C	: Between :San Pasqual : Dam site : and : Hodges : Dam
1937-38 October November December January February March April May June July August September	50 80 340 460 1,960 20,310 3,190 1,920 860 320 100 40	40 70 270 370 1,580 16,330 2,560 1,540 700 250 80 40	40 40 190 240 1,470 25,850 2,890 1,480 530 200 90 20	0 20 410 1,030 4,550 50,240 3,280 1,850 0	0 20 410 1,030 2,280 33,220 720 310 0 0	0 0 80 200 460 6,530 450 160 0 0
TOTALS	29,630	23,830°	33,040	61,380	37,990	7,880
1938-39 October November December January February March April May June July August September TOTALS	90 130 860 1,070 4,010 2,100 1,490 710 210 50 0 130	100 160 1,020 1,260 4,750 2,490 1,760 830 250 60 0 140	60 90 930 1,360 6,060 2,860 1,900 840 100 20 0 60 14,280	0 0 3,230 3,950 11,600 6,760 2,880 0 0 0 0 0 350 28,770	0 0 1,590 2,190 6,850 4,270 1,120 0 0 0 0 350 16,370	0 0 330 450 1,410 880 230 0 0 0 0 350
1939-40 October November December January February March April May June July August September TOTALS	90 130 160 680 1,890 1,040 2,360 500 120 10 0	50 80 100 410 1,130 620 1,420 300 70 0 0	50 70 100 880 2,130 1,010 2,680 430 90 0	0 10 120 940 4,040 1,460 3,980 40 0 0	0 10 120 930 1,640 840 2,560 40 0 0	0 0 20 130 220 110 350 10 0 0

	:		•	:	D-4	: Between
		Between	. Typhanan	: Between :	Between Pamo Dam	:San Pasqual : Dam site
	: Above :	Sutherland Dam and	: Between : Pamo and	:Sutherland :	site and	: and
Congon	: Above : :Sutherland:	Pamo	:San Pasqual	: Dam and :	Hodges	: Hodges
Season and month			: Dam sitesb	:Hodges Dam ^C :	Damc	: Dam
	· Dom ·	Dain DIGC		VIII		
1940-41		=-	22	00	00	0
October	30	50	30	20	20 20	0
November	100	110	90	20 7,540	√5,520	1,570
December	2,470	2,700 1,380	3,510 1,630	4,210	2,150	610
January February	1,270 3,910	4,280	5,950	13,270	8,520	2,410
March	15,100	16,520	24,620	41,180	24,660	7,000
April	13,830	15,140	22,380	42,130	26,990	7,650
May	3,760	4,120	5,620	18,290	14,170	4,020
June	1,420	1,560	1,850	8,890	7,330	2,080
July	´590	650	670	0	0	0
August	340	380	350	0	0	0
September	190	200	190	0	0	0
TOTALS	43,010	47,090°	66,890	135,550	89,380	25,340
1941-42						
October	450	630	540	400	0	0
November	470	630	570	2,280	800	250
December	960	1,320	1,320	9,030	7,710	2,200
January	1,770	2,430	2,640	7,130	4,700	1,350
February	1,210	1,670	1,700	3,600	1,930	550
March	1,670	2,290	2,460	5,240	2,950	850
April	1,360	1,870	1,980	1,830	0	0
May	860	1,170 420	1,150	220 100	0	0
June	310 60	90	3 <i>5</i> 0 90	0	0	0
July August	o o	0	0	0	0	ő
September	Ö	0	Õ	Ŏ	Ö	Ö
_						
TOTALS	9,120	12,520 ^c	12,800	29,830	18,170	5,200
1942-43						
October	30	30	20	0	0	0
November	90	50	60	0	0	0
December	200	120	100	250 6 h70	250	40 850
January	2,870 1,880	1,720	2,740 1,630	6,470 2,520	4,760 750	140
February March	5,620	1,130 3,370	5,780	13,940	10,570	1,920
April	5,080	3,050	5,220	4,880	1,830	330
May	1,500	900	1,230	90	0	0
June	580	360	350	0	Ō	Ō
July	140	80	50	0	0	0
August	30	10	10	0	0	0
September	0	0	0	0	0	0
TOTALS	18,020	10,820°	17,190	28,150	18,160	3,280
TOTATIO	10,020	20,020	×13-70	20,270		5,200

	:	D-4	•	:		: Between
		Between Sutherland	: . Dodano en	: Deduce on	Between	:San Pasqual
	: Above :			: Between :	Pamo Dam	
Canaan	: Above : :Sutherland:	Pamo	: Pamo and	:Sutherland :	site and	: and
Season and month			:San Pasqual : Dam sites ^b	: Dam and :	Hodges Dam ^c	: Hodges : Dam
	· Dant ·	Dan Sive	· Dall Sives	:Hodges Dam ^C :	Daili	· Dalli
1943-44	1.0					
October	40	20	10	0	0	0
November	90	30	30	0	0	0
December	490	220	170	630	180	40
January	500	240	170	530	150	40
February	3,760	2,400	2,540	5,250	1,490	370 60
March April	4,690	2,280 610	3,340	900	250 420	
_	1,700 960	310	790 270	1,470 210	60	100 20
May June	560	280	370 210	180	50	10
July	110	90	50	0	0	0
August	10	10	0	0	0	0
September	0	0	0	0	0	0
_						
TOTALS	12,910	6,490	7,680	9,170	2,600	640
1944-45						
October	0	10	0	0	0	0
November	490	310	200	870	870	490
December	300	120	120	560	560	320
January	280	150	90	570	570	320
February	760	490	350	20	20	20
March	4,340	2,540	3,570	5,420	1,310	740
April	2,010	750	1,180	690	0	0
May	760	230	320	0	0	0
June	370	120	150	0	0	0
July	50	20	30	0	0	0
August	200	10	70	0	0	0
September	<u>60</u>	0	10	0	0	0
TOTALS	9,620	4,750	6,090	8,130	3,330	1,890
1945-46						
October	60	0	40	0	0	0
November	110	20	50	0	0	0
December	3,380	1,900	4,090	5,120	3,770	. 1,360
January	980	300	630	160	0	0
February	570	220	340	540	70	40
March	830	330	530	530	0	0
April	850	450	550	690	0	0
May	330	150	190	0	0	0
June	30	30	30	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	20	0	0	0	0	0
TOTALS	7,160	3,400	6,450	7,040	3,840	1,400
2 7220	1,200	3,	- , , , , -	1,000	3,2.0	

Season and month	: Above : :Sutherland:	Pamo :	Between Pamo and San Pasqual Dam sites	: Between : Sutherland : Dam and : : Hodges Dam ^c :	Between Pamo Dam site and Hodges Dam ^C	: Between :San Pasqual : Dam site : and : Hodges : Dam
1946-47 October November December January February March April May June July August September	40 740 360 320 320 440 220 40 10 0	0 290 220 160 120 230 180 30 0 0	10 610 290 270 290 270 120 40 20 0	0 0 260 130 0 0 20 0 0 0	0 0 260 130 0 0 20 0 0 0	0 0 220 90 0 0 0 0 0
1947-48 October November December January February March April May June July August September TOTALS	0 10 130 70 240 340 340 50 20 0	0 0 10 30 140 120 60 40 10 0	10 30 90 40 110 150 90 30 10 0	0 0 180 0 0 0 0 0 0 0 0 0	0 0 180 0 0 0 0 0 0 0 0	0 0 120 0 0 0 0 0 0 0 0
1948-49 October November December January February March April May June July August September TOTALS	0 0 40 510 1,120 1,280 950 390 130 0 0	0 0 0 370 440 420 200 180 0 0 0	10 10 50 390 470 380 230 130 30 0 0	0 0 30 70 0 70 0 0 0 0	0 0 30 70 0 70 0 0 0 0	0 0 40 0 50 0 0 0

	:	•		:		: Between
	:	Between :		:	Between	:San Pasqual
		Sutherland: 1	Between	: Between :		: Dam site
			Pamo and	:Sutherland :	site and	: and
Season	:Sutherland:		an Pasqual	: Dam and :	Hodges	: Hodges
and month	: Dam ^a :	Dam site : 1	Dam sitesb	:Hodges Dam ^C :	Dam ^C	: Dam
1949-50						
October	0	0	0	0	0	0
November	Ö	Ö	10	0	0	0
December	60	Ö	50	0	0	0
	340	150	160	50	50	0
January	560			-	10	_
February March	340	3 <i>5</i> 0 110	230 110	10		0
	200	110	80	0	0	0
April	140	40	40	0	0	0
May				0	0	0
June	10	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
TOTALS	1,650	760	680	60	60	0
1950-51						
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	0	0	90	0	0	0
January	170	90	100	0	0	0
February	140	90 70	70	0	0	0
March	300	90	130	Ö	0	0
April	130	150	70	0	0	Ö
May	90	50	10	Ö	0	Ö
June	90	0	0	0	0	0
July	Ö	ő	Ö	Ö	0	Ö
August	Ö	0	0	ő	0	0
September	Ö	0	Ö	Ö	0	0
pehremper					<u>~</u>	
TOTALS	830	450	470	0	0	0
1951-52						
October	0	0	0	0	0	0
November	0	0	0	0	0	0
December	1,190	1,550	840	140	0	0
January	3,770	3,300	3,880	4,570	2,040	0
February	990	390	270	0	0	0
March	10,010	4,230	7,670	8,720	5,210	910
April	3,490	920	1,460	1,780	1,360	180
May	1,390	670	410	220	190	0
June	650	170	160	0	0	0
July	120	0	30	0	0	0
August	10	0	0	0	0	0
September	0	0	0	40	40	40
		11 020	11, 720	15 1:70	8,840	
TOTALS	21,620	11,230	14,720	15,470	0,040	1,130

	: Above	Between Sutherland Dam and	Between Pamo and	: Between : Sutherland :	Between Pamo Dam site and	: Between :San Pasqual : Dam site : and
Season and month	:Sutherland: : Dama , :	Pamo	San Pasqual Dam sites ^b	: Dam and : : Hodges Dam ^C :	Hodges Dam ^C	: Hodges : Dam
1952-53						
October	0	0	0	0	0	0
November	80 240	0 160	110 210	· 0	0 30	0
December January	470	530	320	30	20	Ö
February	260	80	110	0	0	0
March	510	160	220	0	,0	0
April	180	110	130	50	40	30
May	210 40	100	90	0 20	0 10	0 10
June July	40	20 0	30 0	0	0	0
August	Ö	ŏ	ő	ŏ	Ö	ő
September	0	0	0	20	20	20
TOTALS	1,990	1,160	1,220	160	120	60
1953-54						
October	0	0	0	120	70	10
November	0	0	0	90	50	10
December	50	0	10	100	70	10
January	190	200 310	220 270	140 130	110 90	20 20
February March	330 2,600	2,260	3,340	2,720	90 440	80
April	1,100	350	340	150	90	20
May	300	100	70	70	10	10
June	80	10	30	80	20	10
July	10	0	0	80	20	10
August	0	0	0	70 100	10 40	10 40
September	-					
TOTALS	4,660 ^d	3,230	4,280	3,850	1,020	250
1954-55						
October	0	0	0	100	50	40
November	10	0	0	90	50 40	30 10
December January	30 200	40	10 150	70 80	50 50	20
February	130	40	80	Ö	Ô	0
March	140	50	90	0	0	0
April	40	10	30	0	0	0
May	60	20	40	0	0	0
June July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	ő	0	Ö	ŏ	Ŏ	ő
	610 ^d					100
TOTALS	9T0~	160	400	340	190	100

Season and month	: Above : Sutherland:	Pamo :	Between Pamo and San Pasqual Dam sitesb	: Between :Sutherland : Dam and :Hodges Dam ^C	Hodges	: Between :San Pasqual : Dam site : and : Hodges : Dam
1955-56 October November December January February March April May June July August September TOTALS	0 0 20 350 190 80 100 40 0 0	0 0 0 550 110 60 60 10 0 0	0 0 10 870 90 50 60 30 0 0	0 0 10 110 0 10 10 0 0 0	0 0 10 30 0 10 10 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
1956-57 October November December January February March April May June July August September	0 0 170 200 200 90 150 20 0 0	0 0 0 30 30 120 10 100 0 0	0 0 70 60 80 40 70 0 0	0 0 0 180 0 0 0 0 0 0	0 0 0 180 0 0 0 0 0 0	0 0 0 150 0 0 0 0 0

a. Recorded values.

b. Assuming no regulation or losses from present operation of San Pasqual Basin.

c. Assuming conditions of present land and water use in San Pasqual Basin.

d. Recorded values corrected for rainfall on reservoir surface.



APPENDIX E

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS AFFECTING SAN DIEGUITO RIVER WATERSHED

TABLE OF CONTENTS

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS AFFECTING SAN DIEGUITO RIVER WATERSHED

Table No.		Page
E-1	Estimates of Seasonal Imports and Exports by City of San Diego	E- 3
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E-8	Estimates of Seasonal Imports and Exports by Del Mar Utilities	E-13

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS BY CITY OF SAN DIEGO

Area in acres in 1957: 84,170

Population in 1957: 494,200

Original member of San Diego County Water Authority formed June 9, 1944
Preferential Right to purchase water from San Diego County Water Authority in 1957: 69.24 per cent of total deliveries, 135.71 second-feet Assessed valuation 1957-58: \$648,427,780

rts	Total	-3,100 -3,330 -3,580	-3,640 -4,380 -3,500 -3,700	-3,790 -3,640 -3,610 -3,650 -3,410
imports or exports	San Dieguito: River Water	-3,100 -3,300 -3,580	640 640 640 640 640 640 640 640 640	-3,790 -3,640 -3,650 -480
Net imp	San Luis Rey River Water	000	00000	078-
	Colo- rado River Water	000	00000	3,730
00	Total	3,100 3,330 3,580	3,640 4,380 3,500 3,700 3,820	3,790 3,640 3,610 3,650 3,180
Exports	: :San Dieguito: : River : Water :	3,100 3,330 3,580	3,640 4,380 3,500 3,820	3,790 3,640 3,610 3,650 480
Exp	San Luis Rey River Water	000	00000	0 0 0 0 0 0 7 8
	do do ver ter	000	00000	00001,860
00	Total	000	00000	0 0 0 5,590
Imports	Colo- :San Luis: rado : Rey : River : River : Water : Water :	000	00000	00000
		000	00000	0 0 0 0 5,590
	Season	1936-37 38 39	1939-40	1944-45 46 47 48 49

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS BY CITY OF SAN DIEGO (continued)

In Acre-Feet

rts	•		: Total		1	1,540	4,290	-3,270	-4,240	-7,600	4,380	5,780	000 *9	
Net imports or exports		:San Dieguito:	River	Water		26	- 370	-3,270	-4,240	-7,600	- 80	077 -	-1,360	The state of the s
Net impo	Colo- :San Luis:	Rey	River	Water : Water :		-150	0	0	0	0	0	0	0	The Court of the C
	Colo-	rado	River	Water		1,780	7,660	0	0	0	7,460	5,820	7,360	Section Care
	-0		. Total :	00		3,730	3,750	3,270	4,240	7,600		3,100		
25.00		San Dieguito:	River	Water		96	370	3,270	4,240	7,600	80	07	1,360	
Exports	n Luis:	: Rey :Sar	liver :	Water :		150	0	0	0	0	0	0	0	
	Colo- :San Luis:	rado :	River : River	Water : W			3,380		0	0	3,200		2,710	
		00	: Total :	00		5,270	8,040		0	0	7,660	8,880	10,070	
Tmnowta	San Luis	Rey	River	Water		0	0	0	0	0	0	0	0	
	Colo- :San Luis:	rado .	. River :			5.270	070,8	0	0	0	7.660	8,880	10,070	
		Season				1949-50	27	52	53	77	٠ ۲	26	57	

ESTIMATES OF SEASONAL IMPORTS BY RINCON DEL DIABLO MUNICIPAL WATER DISTRICT**

Area in acres in 1957: 22,318

Population in 1957: 12,275

Preferential right to purchase water from San Diego County Water Authority in 1957: 1.60 per cent Date annexed to San Diego County Water Authority: June 14, 1954

of total deliveries, 3.14 second-feet Assessed valuation 1957-58: \$16,580,520

In Acre-Feet

* Based on records of metered sales within that portion of Improvement District No. 1 lying within San Dieguito River watershed, and does not include imports by Escondido Mutual Water Company.

ESTIMATES OF SEASONAL IMPORTS BY ESCONDIDO MUTUAL WATER COMPANY

Area in acres in 1957: 14,500
Fopulation in 1957: 6,500
Assessed valuation 1957-58: \$13,845,000

In Acre-Feet

Total	850 1,240 1,400	1,640b 1,340 1,370 1,910 1,950	1,880b 2,470b 2,310 2,630 2,440	2,800 2,910 2,690 4,070c 4,240c	4,920c 4,990c 4,850
San Luis Rey River Water :	850 1,240 1,400	1,640 1,340 1,970 1,950	1,880 2,470 2,310 2,630 2,440	2,800 2,910 2,690 4,070 4,240	2,300 2,090 2,750
: Colorado River Watera :	000	00000	00000	00000	2,620 2,900 2,100
Season	1936–37 38 39	1939–40 41 42 43 43	1944-45 46 47 48 49	1949–50 51 52 53 54	1954–55 56 57

in the San Diego County Water Authority. Based on data presented in United States Department of Agriculture Soil Conservation Service report Colorado River water received by virtue of Rincon del Diablo Municipal Water District's membership ĝ ಕ

entitled, "The Water Supply of Escondido Soil Conservation District", February, 1947.

Based on metered sales within that portion of Escondido Mutual Water Company lying within San Dieguito River watershed. ပိ

ESTIMATES OF SEASONAL IMPORTS BY CITY OF ESCONDIDO*

Area in acres in 1957: 2,014

Population in 1957: 10,050

Date annexed to San Diego County Water Authority: October 9, 1950

1.28 per cent

Preferential right to purchase water from San Diego County Water Authority in 1957: of total deliveries, 2.51 second-feet Assessed valuation 1957-58: \$14,711,500

	Total	50 50 50	0,4 0,0 0,0 0,0 0,0 0,0 0,0 0,0 0,0 0,0	990 900 900 900 900 900 900	70 100 120	140 150 150
Imports	San Luis Rey River Water :	50 50	0,4 0,0 0,0 0,0 0,0 0,0 0,0 0,0 0,0 0,0	60 70 00 00 00 00 00	20 20 50 50 50	80 30 20
	: Colorado River Water : Sa	000	00000	00000	30 S O V V V V V V V V V V V V V V V V V V	80 120 130
	Season	1936-37 38 39	1939-40 41 42 43 43	1944-45 46 47 48 48	1949-50 51 52 53 54	1954-55 56 57

^{*} Based on ratio of number of accounts within San Dieguito River watershed to total number of accounts, applied to total use by the City of Escondido.

ESTIMATES OF SEASONAL IMPORTS BY POWAY MUNICIPAL WATER DISTRICT*

Area in acres in 1957: 10,800
Population in 1957: 1,560
Date annexed to San Diego County Water Authority: April 21, 1954
Preferential right to purchase water from San Diego County Water Authority in 1957: 0.21 per cent

of total deliveries, 0.41 second-feet Assessed valuation 1957-58: \$2,295,230

1953-54 1954-55
1955–56 1956–57

^{*} Based on records of metered sales within that portion of Poway Municipal Water District lying within San Dieguito River watershed,

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS BY SANTA FE IRRIGATION DISTRICT*

Preferential Right to purchase water from San Diego County Water Authority in 1957: 0.92 per cent of total deliveries, 1.80 second-feet
Assessed valuation 1957-58: \$9,374,930 Area in acres in 1957: 10,106
Population in 1957: 5,575
Date annexed to San Diego County Water Authority: December 13, 1948

S		IOTAL	-1,230	-1,420	-1,450	-1,390	-1,240	-1,300	-1,540	-1,540	-1,250	-1,870	-1,730	-1,540	850
rts or exports	San Dieguito:	Mater	-1,230	-1,420	-1,450	-1,390	-1,240	-1,300	-1,540	-1,540	-1,250	-1,870	-1,730	-1,540	- 240
Net imports	is	Mater	0	0	0	0	0	0	0	0	0	0	0	0	1,410
	Colo- rado	Water	0	0	0	0	0	0	0	0	0	0	0	0	-320
		Iotal	1,230	1,420	1,450	1,390	1,240	1,300	1,540	1,540	1,250	1,870	1,730	1,540	1,610
S	Dieguito	Water	1,230	1,420	1,450	1,390	1,240	1,300	1,540	1,540	1,250	1,870	1,730	1,540	240
Exports	is: :San														
	:San Lu :Rey	. Water	0	0	0	0	0	0	0	0	0	0	0	0	750
	Colo- rado	Mater	0	0	0	0	0	0	0	0	0	0	0	0	950
		Total	0	0	0	0	0	0	0	0	0	0	0	0	2,460
Imports	San Luis Rey	Water	0	0	0	0	0	0	0	0	0	0	0	0	1,830
••	Colo- rado	. Mater	0	0	0	0	0	0	0	0	0	0	0	0	630
	Season		1936-37	38	39	1939-40	7	74	£3	7.	1944-45	947	147	847	64

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS BY SANTA FE IRRIGATION DISTRICT* (continued)

In Acre-Feet

	40	Imports		*0		Exports			Net im	Net imports or exports	export	S
	: Colo-	Colo- :San Luis:	ŝ	: Colo-	lo- :San Luis:	ő		Cc10-	: Colo- :San Luis:	ະຕິ	69	
Season	: rado :	: Rey	••	do	: Rey	:San Dieguito:	•	rado	: Rey	:San Dieguito:	guito:	
	: River :	: River	: Total	: River	: River	: River	Total	River:	: River	: Riv		Total
	: Water	: Water	0.0	: Water :	: Water	. Water		Water	Water : Water	: Water	er.	
049-20		220	3,050		09	07	1,620		160	ı	07	1.430
51	450	0	450	1,570	0	170	1,740	-1,120	0	- 170		-1,290
52		0	0	0	0	1,400	1,400%		0	4,1-		-1,400
53	0	0	0	0	0	1,620	1,620*	0	0	-1,6		-1,620
54	0	0	0	0	0	1,640	1,640%	0	0	-1,6		-1,640
55		0	0947	ب	0	50	1,880*		0	ı		-1,420
26		0	089	`~i	0	30	1,980%	-1,270	0	1		-1,300
57	1,120	0	1,120	1,540	0	210	1,750		0	1	210	- 630

* Based on records of metered sales of that portion of Santa Fe Irrigation District lying outside San Dieguito River Watershed.

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS BY SAN DIEGUITO IRRIGATION DISTRICT*

Area in acres in 1957: 3,996 Population in 1957: 11,820

Date annexed to San Diego County Water Authority: December 13, 1948

Preferential Right to purchase water from San Diego County Water Authority in 1957: 1.08 per cent of total deliveries, 2.12 second-feet
Assessed valuation 1957-58: \$10,724,020

	ts		• • • •	: Total	-1.990	-2,080	-1,970	-1.990	-1,630	-1,990	-2,270	-2,340	2	-2,670	-2,840	-3,020	-2,370	. 50
	ts or exports		:San Dieguito	River	-1,990	-2,080	-1,970	-1,990	-1,630	-1,990	-2,270	-2,340		-2,6/0	-2,840	-3,020	-2,340	- 350
	Net imports	:San Luis:	Rey	. Kiver	0	0	0	0	0	0	0	0	(>	0	0		780
	CHECKLES OF THE PARTY OF THE PA	Colo	rado	Mater	0	0	0	0	0	0	0	0	(>	0	0	0	-380
		80	- E	Total :	1,990	2,080	1,970	1,990	1,630	1,990	2,270	2,340	027	2,0(2	2,840	3,020	2,340	2,310
	rts			Mater	1,990	2,080	1,970	1,990	1,630	1,990	2,270	2,340	027 0	2,000	2,840	3,020	2,340	350
	odxii	San Luis:	Rey :San	miver: Water :	0	0	0	0	0	0	0	0	c	>	0	0	0	019
		Colo-	F .	Mater:	0	0	0	0	0	0	0	0	c	>	0	0	0	1,350
		•0	00 1	FOTAL S	0	0	0	0	0	0	0	0	c	>	0	0	0	2,360
The Charles of the Ch	Imports	Colo- :San Luis:	Rey	Water :	0	0	0	0	0	0	0	0	C	>	0	0		1,390
The state of the s		0105 :	rado :	. Water :	0	0	0	0	0	0	0	0	C	>	0	0	0	970
			Season		1936-37	38	39	1939-40	7	24	73	7-7-1	701.1.1.5	くせーせせんト	947	27	847	67

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS BY SAN DIEGUITO IRRIGATION DISTRICT* (continued)

In Acre-Feet

		Imports		00		Exports		00	Net imy	Net imports or exports	ts
	Colo-	Colo- :San Luis	e e	Colo-	Jolo- :San Luis:	00		: Colo- :San Luis:	San Luis	oo m	04
Season	: rado	: Rey	0.0	: rado	: Rey	:San Dieguito:		: rado :	: Rey	:San Dieguito:	00
	: River :	: River	: Total	: River	: River	: River :	Total	: River :	River	River	: Total
	: Water	: Water	0.0	* Water :	: Water	: Water :		: Water : Water	Water	: Water	
1949-50		170	1,310	2,320	100	09	2,480	-1,180	20	09 -	-1,170
Z.	1,740		1,740	2,260	0	250	2,510	- 520	0	- 250	- 770
52		0	0	0	0	2,430	2,430	0	0	-2,430	-2,430
53	0	0	0	0	0	3,130	3,130	0	0	-3,130	-3,130
54	0	0	0	0	0	3,220	3,220	0	0	-3,220	-3,220
55		0	1,080	3,050	0	8	3,130	-1,970	0	8	-2,050
56		0	1,310	3,250	0	07	3,290	-1,940	0	07 -	-1,980
57	1,090	0	1,090	2,880	0	007	3,280	-1,790	0	00† -	-2,190

* Based on records of water used furnished by San Dieguito Irrigation District.

TABLE E-8

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS BY DEL MAR UTILITIES

Area in acres in 1957: '1,520 Population in 1957: 2,918 Assessed valuation 1957-58: \$5,000,000

	Total	100	- 90 - 90 -110 -120	-170 -190 -190 -190
orts	_	777		77777
or exports	:San Dieguito: River Water	1000	- 90 - 90 -110 -120	-170 -190 -190 -30
Imports	San D	1 1 1	8 1 (1 1) 1	
Net imp	San Luis: Rey River Water	000	00000	20000
N	1			ĵ.
	Colo- rado River Water	000	00000	0001
00	Total :	0000	989188	170 190 190 190
		- האר	ннн	ппппппппппппппппппппппппппппппппппппппп
*	Dieguito: River Water	100	120 90 130 130 130 130 130 130 130 130 130 13	170 190 190 30
Exports*	San			
	San Luis: Rey River:	000	00000	00000
	Colo- rado River Water	000	00000	00011
••	Total :	000	00000	00000
9				
Import	San Lu Rey River Water	000	00000	00000
	Colo- : rado : River : Water :	000	00000	00000
	00 00 00 00			
	Season	1936-37 38 39	1939-40	1944-45 46 47 48 48

ESTIMATES OF SEASONAL IMPORTS AND EXPORTS BY DEL MAR UTILITIES (continued)

In Acre-Feet

		Imports		•		Exports*		0.0	Net i	mports or ex	exports
	Colo	:San	luis:	: Colo-	:San Luis:	ຶ່ນ	0.6	: Colo-	:San Luis:	ů	00
Season	: rado	: Rey	00	: rado	: Rey	:San Diegui	:0:	: rado	00	:San Diegui	to:
	: River	. : River	: Total	: River	0.	: River :	: Total	: River	: River	: River :	: Total
	: Water	. : Water	00	: Water	* Water	; Water	90	* Water		; Water	• 0
1949-50	0	0	0	200	10	10	220	-200	-10	-10	-220
T S	0	0	0	200	0	20	220	-200	0	-20	-220
52	0	0	0	0	0	220	220	0	0	-220	-220
53	0	0	0	0	0	270	270	0	0	-270	-270
24	0	0	0	0	0	300	380	0	0	-300	-300
55	0	0	0	310	0	10	320	-310	0	-10	-320
56	0	0	0	330	0	10	340	-330	0	-10	-340
57	0	0	0	320	0	50	370	-320	0	-50	-370

* Based on records of water used in that portion of Del Mar Utilities lying outside San Dieguito River Watershed.

APPENDIX F

MINERAL ANALYSES OF WATER

TABLE OF CONTENTS

MINERAL ANALYSES OF WATER

Table No.		Page
F-1	Mineral Analyses of Surface Water in San Dieguito River Watershed	F-3
F-2	Mineral Analyses of Ground Water in San Dieguito River Watershed	F-7

TABLE F-1

MINERAL ANALYSES OF SURFACE WATER IN SAN DIEGUITO RIVER WATERSHED^a

Stream :P	Plate 4:	1.3 6 1.3 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	Date	: Dis- : : : : : : : : : : : : : : : : : : :	ECX106:	语	Miner	Mineral constituents in	tituent	s in	per	parts per million equivalents per million	1111on per mi	111on	•• •• ••	 (Ste	: Total : dis- B :solved		80 60	: Per
uol	tion:	mile :	TimeD	: feet :	25℃:		ස ස		Na.	×	CO3 : F	HCO3 ; S	sa _t	C1 : N	NO ₂ : F	d : mdd	ppm : solids; :	ids,: Ca	CaCO3, :	Na.
							INLAND	INLAND HYDROLOGIC UNIT	GIC UNI	L										
Santa Ysabel Creek, State	H	3€-49-5	1-27-57 1420	20	316	7.4	1.30	0.50	0.76	40.0	00	1:30 0	40 0.83 0	20 0.55 0	2 0.0 0.0	0 9.0		213	90	29
No. 79			3-26-57	30	325	7.9	1.40	0.85	0.90	2 0.04	00	98 1.60 05.1	0.97	20 20 2	0 0 0 0	0.2 0.	0.08	227	211	28
Santa Ysabel Creek, at	8	%-\t1.1	12-12-56 ^d	9	455	9.8	28 1.38	17.41	1,22	0.26	0.12	160 1	0.17	1.50	17.	0.2	1	322	140	35
Sutherland Reservoir			10-16-57 ^d	ŀ	1462	8.8	1.20	1.23	38	0.20	0.20	2.36	20 0.42 1	1:39	0.01	0.3	•	280	128	43
Santa Ysabel Creek, above	6	%-35-7	1-25-51 1530	0°6°0	537	8.0	2.15	18	38	1 1	00	2.32	1:98	1:13	0.02	0		372	181	32
confluence with Temesoal Creek			5- 2-52 ^e 1000	ىر م	313	8.0	1.33	8 0.67	1.13		00	105 2	28 0.58 0	0.76	₽.0 ₽.0	6	0.10	1%	100	%
Santa Ysabel Creek, near Ramona, U.S.G.S. Gaging Station	<i>≠</i>	96-33.8	3-26-57	1	7.0 7.7	7.7	2.50	2.30	2.87	0.08	00	3.30	2.00	2.28 7	0	0.3	%	884	239	×
Santa Ysabel Greek, near San Pasqual, U.S.G.S.	rv	%-29.5	1-10-57 1050	0.10	£	7.3	2.15	3.12	3.83	0.10	00	214 3.51 1	1:73	3.89	0.01	ŏ	0.11	009	263	175
Guejito Creek near San Pasqual U.S.G.S. Gaging Station	9	96-26.0-2.0	1-13-57	20	624	7.3	10 2°00	1.89	2.35	0.07	00	3.06	1:11	2.03	77 7	6	₹.0	380	₹ ₂	33
Unnamed tributary 7 to Santa Maria Greek north of Highland Valley Rd.	ary 7	96-23.5-6.6	1-27-57 1245	0.16	88	6.5	0.25	0.25	0.30	0.05	00	0.50	60.0	0.20	0.01	0 9.0	0.10	75	25	Ж

MINERAL ANALYSES OF SURFACE WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

								/namilia iioo	(20)										
Stream	Plate 4:	Stream	Date	: Dis- : : : : : : : : : : : : : : : : : : :	ECx106:	晋.	Miner	al cons	Mineral constituents in	s în	part	parts per million equivalents per million	1111on per mi	111on	<u></u>		: Total : dis- :solved	: Total : Per : as : cent	Per:
uo	tion :		Timeb	: feet :	1	'	ະ : ຮຽ	 æ	Ne.	ж :	со ³ ; н	HCO3 : S	so _t t	con ; 10	3 : ppm	udd : u	: solids,	: CaCO3,	No.
							CENTRAL	HYDROL	CENTRAL HYDROLOGIC UNIT	II									
Senta Ysabel Creek in San Pasqual Valley at State High- way Route	©	96-26.6	5- 1-52 ^e 80 ^c	80%	357 7.7		1.46 1.46	0.91	1.20 1.20	% 0°0/	00	11.9	94 0.71	0.94 0.06		0.10	216	118	33
Guejito Creek at San Pasqual, U.S.G.S. Gaging Station	•	%-26.0-0.4	5- 1-52°	o ^{††}	533	† • ⊗	43 2°15	97:1	500 200 200	0.05	0.08	3.46 0	0.61	1.58 th		0.10	300	280	%
Santa Maria Greek, in San Pasqual Valley at bridge near Bandy Canyon	90	%-23.5-1.8	5- 1-52° 1510	<u>ي</u>	820	7.4	2.25	2.06	4.23 4.23	0.12	00	25 to	0°89	3,56	0.05	0.10	H62	215	6 11
San Dieguito River near	Ħ	96-21.2	3- 1-51 ^f 1410	0.90	694	8.0	1:70	1.32	38	0.14	00	2.28 1	1.23	μ ₁ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		- 0.14	293	मुरा	ま
San rasqual, U.S.G.S. Gaging Station			1-14-52 1600	99	386	7.8		1 1	1 :	1 1	00	2.56	اا: اا:	26	•1•	;	1	138	:
			$\frac{2-11-52}{1320}$	8	297	8.2	1 1	: :	: :		0 0	3.40	1 1	2.51	11.	;	:	202	;
			3-10-52 1500	300	379	7.7	1 1	1	1 1	: :	00	12 ⁴ 2.0 ⁴		1.21	· : ;	;	•	112	}
			1345	140°	914	7.8		1	1	1 1	00	2.60	11:	元 4:1	· : :		1	1	1
			5-12-52 1 1400	8	565	7.7	1:90	1.48	48 2.09	30.08	olo	3.08	0.8	57 1.61 0.	0.02	0.4 0.13	書	169	38
			6- 9-52 1340	39	746	7.7	1 1	1 1		: :	12 0,40 4	276 4.52	1 1	3.20	· : :	;	9	256	1
			2-16-53 1315	0.36	943	8.3		1 1	; ;	: :	00	349	=======================================	3.89	٥٨.		म अ	304	1

MINERAL ANALYSES OF SURFACE WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

				. 040	1	1						1			1		E	E TOPE	200	1
Stream	Plate 4:			:oharge: ECx106:	ECx106:	• ••	Minere	1 cons	Mineral constituents	t e	점.	parts per	뎉	1	• ••	• ••			: hardness: Per	Per
and	: 100a-	Streem	. Dete	: 1n :	s t	"祖					bé	edulvalents		per million		 (k)	B :sol	: pealos:	8.8	: cent
location	: tion	: mile	. Timeb	: feet :	25°C :	** **	Ca :	Mg	Na	×	603	НСОЭ	: †los	CJ :	NO ₃ :	: mdd	os: mdd	: solids,: C	Cado _{3,}	. Na
						CENTE	CENTRAL HYDROLOGIC UNIT	OLOGIC	UNIT ((continued)	(pe									
San Dieguito River near	Ħ	96.21.2	4-13-53 1405	20	0%	7.3	1 1	11	3.48	: ;	00	283 4.64	1 1	140 3.95	1 :	1	0.10	0	287	1
San Fasqual, U.S.G.S. Gaging Station			5-11-53	0.30	817	7.4	60 2.99	2.30	3.70	0.08	00	1.20	90	124 3.50	0.02	9.0	0.14	538	264	μĵ
			4-12-54 1445	1.50	1,030	8.0	3.39	32 2.63	11.3	0.09	37 0.56	312 5.12	1.15	153	010	1	0.12	621	303	67
			5-13-54 1730	Je	865	7.8	53	238	3.70	0.00	00	268 1,40	1:16	3.21	0.02	9.0	90.0	506	251	142
			6-14-54	0.10	903	1 °8	1	1 1	ı ı	: :	쿼	130	1	125	1 1	;	0.10	ł	506	50
			1-27-56 1300	1	192	7.2	19 0.95	0.58	100年	5.13	00	1.36	0,22	12 0.34	0.03	1	₽.0	130	92	21
San Dieguito River, at San	12	%-19-3	12-20-50 ^d	1	1	ı	<u>ا</u>	1 32	13#	1 1	9 1	216	283	101	1 1	;	;	;	331	147
Viego Aqueduor Weir	u		5- 9-51 ^d	:	1	1	1 32	12	119	: 1 :	13	183	272	<u>ه</u> ا:	0 1	;	:	1	340	₽13
San Dieguito River, at U.S. Highway No. 395	. 13	96-18.0	12- 5-46 ^h		1	!	1 = 1	9] -	70	: :	1	22th	- 1	1	: :	:	ì	+	160	148
San Dieguito River, at Leke Hodges at south end of bridge, U.S. Highway No. 395	th U.S.	96-18.0	4- 7-52	1	η ₂₈	7.7	30	0.99	1:7	80.0	00	136 2.24	0.73	1.49	0.03	1	0.05	280	124	升
San Dieguito River at Lake	큐	%-12.2	12- 5-50 ^d	29.4	;	7.6	4.39	32 2.63	112 4.87	1 :	00	3.54	27.2	2:71	010	;	:	740	351	14.1
hodges outler conduit			5-30-51 ^d	18.08	1	7-7	# * *	2.55	100	1 1	00	3.54	227	2.74	0 0	0 8	:	735	375	37

MINERAL ANALYSES OF SURFACE WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

Streem	: Plate 4:	: : Stream	: : Date	: Dis- : oharge: in :	: Dis- : charge: ECx10 ⁶ : in : at :	E	Mine	ral con	Mineral constituents in	ts in	1 P8	parts per million equivalents per million	million s per n	ullion	•• •• ••	5kg	: Total : dis- B :solved	1	80	. Per
loostion	: tion	: mile	11meb	: feet :	25℃		ဗ္ဗ	Mg	Na :	×	; co3 ;	HCO3 : SOT	SO ₁	נו	NO ₃	d : wdd	mdd: md		:	Na Na
						CENT	RAL HYD	ROLOGIC	UNIT (CENTRAL HYDROLOGIC UNIT (continued)	(pe									
San Dieguito River at Lake	콨	%-12.2	2- 5-53d 10.0g	10.08	538	8°1	1.80	13	2°80	0.13	00	185	38	50 1.42	0.02	0°3	-	318	143	ľή
conduit			8-18-54d 21.08	21.08	617	8.2	35	20	25.曲	0.13	00	3.02	1.04	1.87	2 0°0 ⁴	0.2	P	331	167	<u>भ</u>
			11-29-55 ^d 6.9 ^g	6.98	1,185	8.1	3.84	3.62	135	5.12	00	2.90	347	3.25	0.05	0.2		859	373	54
			10- 3-56 ^d 17.0 ^g	17.08	1,280	8.6	88 4°39	2.79	126 5.48	0.10	0.20	115	7.07	3.59	0.02	. 6.0	•	875	360	t ¹ 3
			1-29-57 ^d 4.68	89°4	1,270	8.0	25.74	2.8	124 5.39	0.18	00	160 2.62	360	3.59	0.02	0.3	1	850	380	42
			10-17-57 ^d	5.98	1,220	7.6	00 11.49	25.88	133	5.14	00	2.18	<u>362</u> 7.53	3.51	1 1 1 0	, †°0	۵ ا	835	369	145
							COASTA	COASTAL HYDROLOGIC	LOGIC U	UNIT										
San Dieguito River	15	96-2.8	3-26- 51 1035	0.5	5,290	7.6	130	4.19	1,000	36 0.42	00	735 13.04	257	37.60	6.0	- 1	1.01 3,	3,120	534	80

Analyses by Department of Water Resources unless otherwise noted.

Pacific Standard Time indicated by 24-hour time system.

Analyses furnished by City of San Diego, Water Department. Estimated.

Analyses by Paolfic Chemical Consultants, Van Nuys, California.
Analyses by United States Geological Survey, Davis, California.
Furnished by United States Geological Survey, Surface Water Branch, Los Angeles, California.
Information received from Escondido Mutual Water Company, Escondido, California.

TABLE F-2

	: Par	Na .			45		#		35		28	ま		53	61	55	8	¥
	Total : hardness: Per es : cent	CaCO ₃ ,			116		168		250		163	212		113	221	256	286	£
	: Total : dis- :	: solids,:			2%		001		412		279	336		332	662	645	1	724
	<u>а</u>	wdd :			0		0		0		0°05	90°0		0°05	90.00	0.08	1	0.20
	ß.	udd			ቱ.0		0.7		† °0		0.2	0.2		0.3	3.0	0.7	1	0.5
	** ** **	NO3			े <u>ज</u>		45		010		010			0.20	37 0.59	0.31	1 1	26 0.42
rg Gi	l e	CJ ;			50		65 1.83		20 1.97		33	3.86		2.09	176	171	3.80	5.18
ATERSH	ton r milli	: hos			37.77		25 0 0 5 5 2		41 0.85		39	1.12		15	31 0.65	6.90	1 1	1.65
TO RIVER 1	parts per million equivalents per million	HCO3			140 2.30		180		3.58		2.36	3.37		142 2.32	312	33# 5°48	315	334 5°48
DIEGUI	parts	600	INIT		00	Basin	00	nstn	00		00	00		00	00	00	ıþ.	00
IN SAN	5		OLOGIC 1	Ballena Basin	5 0.13	Lower Hatfield Basin	2 0.04	Hatfield Basin	0.05	Pano Basin	0.05	0.05	Ramona Basin	2 0.04	0.05	0.04	: 1	0.06
es of ground water in san dieguito river watershed ^a	Mineral constituents in	Na å	INLAND HYDROLOGIC UNIT	Ballen	146 2.00	Lower H	62 2.70	Upper Hat	52 2.26	Pamo	30	49 2.13	Ramone	62 2.70	160	1 6.26	: 1	138
ES OF GRO	neral con	Mg	A		1.23		1.36	P	25.05		1,32	1.89		1.32	2.38	35 2.88	1 1	3.7
MINERAL ANALYS	W.	සට			22		3,80		41 2.05		140	2.40		1.00	41 2.05	45 2.25	111	3.15
MINERA	看	•• ••			7.2		6.9		7.2		8.0	7.8		7.1	7.8	7.7	7.7	7.6
	ECK106				450		999		630		th ¹ 5	630		525	1,007	1,149	1,048	1,080
	Temper : ature :	: GE :			89		89		22		ተ 9	7,9		70	;	;	99	89
	Date	P			4- 5-57 ^b		4- 8-57 ^b		4- 8-57b		3-36-57	3-26-57		3-26-57	7- 9-53	8-27-54	8-1-55	9-12-56 b
	State Wall	: Loqunu			13S/2E-11C1		13S/2E-17C1		138/2E- 9H1		115/1E-35P2	128/1E-11L1		135/15- 3#2	138/18-11141			

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

	: Per	Na.			乱	641	53	25	52	32	59	63	63	38	×	ŧ	39
		CaCO3,			255	185	237	231	247	3€	330	293	179	320	331	323	317
	: Total : dis- : solved :				246	064	260	525	630	956	1,040	p609	655	801	1111	750	1119
	д	ndd			0.02	0	0.10	₹0.0	0.08	0.18	₹0°0	0	0.02	0	0	1	0.02
	βa,	udd			0.7	π°0	6.0	9.0	9°0	†°0	9.0	0.8	0.8	9.0	0.7	8 8	1.0
(panurano)	Mineral constituents in parts per million equivalents per million	Mg i Na i K i CO3 i HCO3 i SO4 i C1 i NO3	INLAND HYDROLOGIC UNIT (continued)	Ramona Basin (continued)	$\frac{35}{2.87} \frac{138}{6.00} \frac{r_{\rm r}}{r_{\rm r}} \frac{0}{0} \frac{329}{5.40} \frac{36}{0.75} \frac{178}{5.01} \frac{5}{0.08}$	$\frac{22}{1.80} \frac{84}{3.65} \frac{2}{0.08} \frac{0}{0} \frac{149}{2.45} \frac{22}{0.46} \frac{143}{1.09} \frac{48}{0.77}$	$\frac{31}{2.55} \frac{124}{5.39} \frac{1}{0.03} \frac{0}{0} \frac{346}{5.68} \frac{36}{0.74} \frac{16}{3.27} \frac{20}{0.33}$	$\frac{29}{2 \cdot 38} \frac{113}{4 \cdot 92} \frac{1}{0.09} \frac{2}{0.09} \frac{22}{0.072} \frac{283}{4 \cdot 64} \frac{41}{0.85} \frac{100}{2 \cdot 82} \frac{38}{0.61}$	$\frac{31}{2.55} \frac{130}{5.66} \frac{1}{0.03} \frac{24}{0.80} \frac{259}{4.24} \frac{40}{0.84} \frac{150}{4.23} \frac{28}{0.45}$	$\frac{4.8}{3.92}$ $\frac{223}{9.70}$ $\frac{5}{0.13}$ $\frac{0}{0}$ $\frac{393}{6.44}$ $\frac{72}{1.50}$ $\frac{309}{8.70}$ $\frac{5}{0.08}$	$\frac{29}{3 \cdot 20} \frac{219}{9 \cdot 52} \frac{5}{0 \cdot 12} \frac{0}{0} \frac{357}{5 \cdot 85} \frac{76}{1 \cdot 58} \frac{303}{6 \cdot 53} \frac{21}{0 \cdot 3^{\frac{1}{4}}}$	$\frac{21}{1.75}$ $\frac{153}{6.65}$ $\frac{3}{0.08}$ $\frac{0}{0}$ $\frac{1.24}{2.04}$ $\frac{22}{0.45}$ $\frac{257}{7.29}$ $\frac{42}{0.68}$	$\frac{23}{1.89}$ $\frac{140}{6.09}$ $\frac{3}{0.08}$ $\frac{0}{0}$ $\frac{124}{2.04}$ $\frac{27}{0.57}$ $\frac{228}{6.49}$ $\frac{47}{0.75}$	$\frac{43}{3.56}$ $\frac{93}{4.01}$ $\frac{2}{0.05}$ $\frac{0}{0}$ $\frac{109}{1.79}$ $\frac{31}{0.65}$ $\frac{250}{7.05}$ $\frac{58}{0.94}$	$\frac{144}{3.69}$ $\frac{85}{3.68}$ $\frac{2}{0.05}$ $\frac{0}{0}$ $\frac{107}{1.75}$ $\frac{28}{0.59}$ $\frac{248}{7.00}$ $\frac{59}{0.95}$	$\frac{45}{3.70}$ $\frac{25}{2.0}$ $\frac{254}{2.0}$ $\frac{254}{2.0}$ $\frac{254}{2.0}$ $\frac{254}{2.0}$	$\frac{45}{3.69}$ $\frac{9^4}{4.09}$ $\frac{2}{0.06}$ $\frac{0}{0}$ $\frac{123}{2.02}$ $\frac{28}{0.58}$ $\frac{250}{7.04}$ $\frac{38}{0.61}$
	Min	 ຮັນ			45	39	14t 2°20	45	148 2,40	93.40	3,40	42 2.12	1:70	2.84 2.84	3.00	2.76	2.65
	:Temper-: : ature : ECxlO6 : pH	25°C :			1,195 7.5	795 7.5	891 7.8	4°8 606	т°8 т%	1,420 7.4	1,740 7.2	1,180 7.5	1,083 7.6	1,138 7.6	1,455 7.9	1,000 7.4	1,135 7.9
	Temper-: ature :	: opled:			63	70	:	<i>L</i> 9	49	49	65	ł	69	:	1	73	1
	Date	De l			3-26-57 ^b	3-26-57 ^b	7- 9-53	8-27-54	8- 4-55	9-13-56 ^b	16P1 4- 9-57 ^b	8-19-53°	8-27-54	8-19-53°	8- 4-55	9-13-56b	1+- 5-57 p
	State well :	number			138/1E-11M 3-26-57 ^b	1582	1541				16P1	1711		IN/1			

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED® (continued)

	Per	. Na.			‡	58	8	2	82	32	39	38	52	击	52	;	541
	Total : hardness: Per	Cogo o			163	169	71	196	209	300	221	241	ま	89	89	100	140
	Total : Total : dis- : hardne				382	512	365	621	111 5	581	894	502	268	280	300	300	405
		mdd.			±0.0	0.03	0	0	† 0°0	0	0.18	0	0	0	0	:	0
	Çt.	mdd			0.3	0.7	₩.0	0.3	0.5	0.3	0.3	9*0	0.1	0.2	0.1	1	0.2
		NO ₃			27 0.43	0.02	0.02	0.55	52 0.83	60	27 0.43	60	te 0.74	52 0.82	47 0.76	: :	0.36
	15				85 2.40	180	2.99	88 2.49	8th 2.37	3.47	2.70	105 2.96	82 2.31	2.00	2.00	87 2.46	3.61
	on millio	sot s			16 0.34	42 0.87	13 0.28	25 0.52	33	143 0°90	44 0.92	1.02	11 0.23	16.0	112 0.24	1 1	0.35
	parte per million equivalents per million	; HCO ₃ ;	(penu		2.71	139 2.28	137	178 2.92	3.00	35.5	3.16	180 2.95	422 0.69	08.0	44 0.72	50 全	94°0°
	parte	603	(oont	rtimed)	00	00	00	00	00	00	00	00	00	00	00	00	00
(מפוודים ווחפים)	ıts in	×	GIC UNIT	81n (00n	0.09	0.10	0.05	0.04	0.03	2 0.04	0.05	0.05	0°0	0.03	2 0°0	: :	2 0.0
	Mineral constituents in	Na	INLAND HYDROLOGIC UNIT (continued)	Ramona Basin (continued)	60 2.61	110	60 2.61	60 2.62	60 2.61	66 2.87	2.83	3.0 3.0 3.0 4.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5	2.09	48	14° 5° 00	: :	2.35
	fineral c		INLAN		1.56	1.89	1.23	25 2.02	2.38	3.21	2.38	32 2.62	0.85	0.99	0.99	1:12	1.40
	1	යි			1:70	1.50	33	1.30	1.80	2.79	41 2.04	2.20	1.04	16 0.80	0.80	0.88	13.40
	71.				7.4	7.6	7.7	7.4	8.0	8.1	7.5	7.4	6.8	7.9	7.1	6-9	6.7
	ECx106	25°C			615	840	591	621	689	824	645	870	1111	438	386	1400	578
	Temper -: ature :	sampled:			89	1 9	89	1	1	;	:	1	1	1	1	72	;
	Date	sampled			3-56-57	3-26-57	3-26-57	8-19-53°	8-27-54	8- 4-55	9-13-56 ^b	3-27-57b	8-19-53°	8-27-54	8- 4-55	9-13-56 ^b	12-18-57
	State well :	number :			13S/1E-23B1	27151	29P1	13S/1W-12R1					24R1				

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

Per	cent: Ne			51		32		%		32	30		011			31	145	04
Total :	3			107		17		133		911	120		319			515	317	300
	solids;			2%		173		762		ħ/2	230		700			466	821	099
	ndd :			0.01		0		0		0.03	0		0			0.10	0.10	0,10
F	udd			0.1		0.1		η°0		0.2	0.1		9°0			0.2	9°0	ħ°0
	NO3			0° 48		0.09		16		50.08	0.08		20			110	25 1.54	55 0.89
IE	. CJ			2.76		0.37		40 1.13		37	30		3:75			163	3.98	3.10
lon miliic	so _t			20 0°42		0.18		0.25		31 0.64	10		57.19			1203	3.47	2.73
parts per million equivalents per million	нсоз	(pen		0.80		<u>23</u> 1.53		160		108	145 2°38		317, 5.20			243 3°98	172 2.82	3.15
parte p	603	(contin	(penut;	00	Basin	00	Basin	00	usin	00	00	usin	00	C UNIT	=1	00	00	00
s fn	× ••	IC UNIT	in (con	0.06	a Teress	2 0°04	a Terese	0.05	Senta Yeabel Basin	0.03	3 0.07	Wash Hollow Basin	3 0.07	YDROLOGI	Felioita Basin	3 0.07	1 0°02	0°0
nstituent	Ne.	INLAND HYDROLOGIC UNIT (continued)	Ramona Basin (continued)	2.26	East Santa Teresa Basin	16	West Santa Teresa Basin	35	Senta Y	27	1.09	Wash H	100	CENTRAL HYDROLOGIC UNIT	Pelio	10t t-52	120	4.00
Mineral constituents in	M _G	INLAND	Œ1	1012		0.73		1.31		1,14	12 0.98		3.03			66 5.43	4.03 4.03	3.11
	Ca			1.00		14 0.70		27		25	29 1.45		3.35			4.8H	2.3	2.85
	5 .			7.1		7.6		7.7		6.7	7°4		7.0			7.3	7.8	7.3
EC_106	25°C			200		221		0#		370	380		1,045			1,302	1,197	1,035
	sampled:			1		69		:		2,1	53		99			89	62	89
4	pate sampled			3-27-57 ^b		10-27-57		9-8-57b		3-26-57	3-26-57 ^b		4- 8-57 ^b			3-26-57	3-26-57	3-26-57 ^b
	state well:			13S/1W-24R2		13S/2E- 4J1		12S/2E-32G1		128/3E-1601	2801		13S/2E- 9N1			12S/2W-24\$2	24R3	26Н3

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED[®] (oontinued)

		E																
Date		ature:	ECx106	ቸ Έ		Mineral constituents in	onstituen	its in	parts equival	parts per million equivalents per million	on million	ıe	• •• ••	β.,	æ	rotal : dis : solved :	: Total : :hardness: Per : as :comt	Per commt
eempled		: aampled:	"		g S	M _G	Na	×	600	HCO3	; †os		NO3 :	: mdd		solids;	CaCO3,	RA Ra
						CENT	CENTRAL HYDROLOGIC UNIT (continued)	LOGIC UN	IT (cont	(penut								
						E.	Felicita Basin (continued)	lasin (00	ntinued)									
8	3-26-57	65	1,067	7.1	2.94	% %	107	0.09	00	3.83	2.47	3.24	64.0	ት •0	0	672	295	∄
41	3- 5-57 ^b	68	1,360	7.2	86 1-30	52 4.26	104	0.10	00	241 3.95	2.29	158 14.45	130	0.2	0	880	428	35
-	4- 8-57 ^b	70	1,635	7.3	2.00	65 5.33	121 5.26	0.18	00	265 4.35	104 2.17	260 7.32	33	0.5	0	1,000	516	ま
	4-8-57 ^b	70	760	7.2	37,	24 1.97	81 3.52	0.06	00	125 2.05	1.9	105 2.96	元 0。7 4	0.7	0.02	084	191	84
	4- 8-57 ^b	69	0%	7.6	2.80	30 2.46	3.87	0.10	00	2.90	1:13	145 4.08	62	1°0	0	009	263	η ₂
							Lake	Lake Hodges Basin	as In									
	4- 5-57b	89	1,185	7.8	3.60	3.03	110	0.10	00	268 4.40	29 1.65	175 4-93	8 0.14	ት •0	0	260	331	42
	4- 5-57b	67	820	7.6	43	2.21	3.17	3 0.07	00	143 2.35	27 0.56	153	21 0.34	ħ*0	0	864	218	41
	8-25-54	ł	1,128	7.4	89. 14.	3.04	128 5-57	0,02	00	349	128	167	0.05	† •0	0.10	760	374	42
	8- 4-55	65	1,587	8.2	92 4.60	3.23	1111	0.05	00	277 4.55	3.28	176 4.95	10.0	ή°0	90.00	767	391	38
	8- 2-56	99	1,235	7.4	5.20	3.25	1.02	0.04	00	326 5.35	3.66	3.50	60.0	0.3	90.0	779	H22	32
	4- 5-57b	19	1,160	6.8	1.20 1.20	3.93	3.91	0.05	00	311	3,29	3.52	3 0.05	9°0	ुं इं	790	90 1 1	32

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED⁸ (continued)

	Per : cent	Na Na			641	£	58	45	45	£ .	3	3	£	‡	52	53	. 51
	: Total : :hardness: Per : as :cent	CaCO 3,			220	307	h22	425	419	375	345	333	348	250	388	352	254
ı	: Total : : dis- : : solved :	solids,: CaCO3,			570	721	1,217	916	830	774	700	940	999	429	9/48	808	699
	д	ndd			Ó	90°0	0.20	0.2	90.00	₹°°°	90°0	0.02	₹°°°	0°5	0.07	0.2	0
	Çt.,	wdd			0.7	0.5	1.0	0.2	ካ•0	0.3	0.3	0.7	⊅°0	0.2	0.3	ካ°0	0.5
		N03			olo	0.02	010	0.01	0.03	0.02	0.05	010	0.01	0.03	0.10	olo	28 0.45
	ış	CJ ;			3.21	180 5.08	392	253	232 6.54	200	168	170 4.79	168 4.74	143 4.02	245 6.90	200	188 5-31
	on m1111c	SOL			1:17	78	2.65	<u>25</u> 1.55	1.53	65 1.35	1.16	64 1.33	1:06	64 1.34	900	22,1.65	63
	parts per million equivalents per million	нсоз:	(penu		3.50	270 4.43	359 5.88	1117	415 6.80	298 4.88	%; ₹	330 5.40	380	3.88	朝	3.53	289 4.74
	parts pequival	603	T (continued)	es în	00	00	00	00	00	1 1 1	00	00	00	00	00	00	00
	te in	×	OGIC UNI	San Pasqual Basin	2 0.0	0.00	10.00	2 0.04	0.04	2 0.04	0.03	0.03	0.03	2 0°0	2 0.04	0.08	0.03
	natituen	Na	CENTRAL HYDROLOGIC UNIT	San P	4.22	113	264 11.48	7:12	160	140 6.09	124 5.40	132 5.74	120 5.22	92 4.00	194 8°44	186 8.10	35.0
	Mineral constituents in	Mg	CENTRA		25.05	25 2.88	51 4.19	175 3°46	51 4.19	3.21	33 2.75	40 3.28	25 2.88	2.36	35 2.84	3.21	26 2.12
	E	සිට			2.35	66 3.29	86 14.29	101	84 4.19	86 4.29	83	67 3.35	82 4.09	53	4.91	77 3.84	2.97
	·· ·· ··				7.1	7.3	7.5	7.3	7.6	8.6	7.7	2.6	7.4	7.8	7.4	8.0	6.9
	ECX106	25°C :			895	1,136	2,012	1,520	1,358	1,200	1,242	1,235	1,053	875	1,570	1,300	1,210
	:Temper-: : ature : ECxlO ⁵ : when : at	ן ק			69	69	89	1	1	:	70	89	;	72	1	77	;
	Date :	7			4- 5-57 ^b	3-26-57	3-26-57	8-19-53°	8-25-54	8- 4-55	8- 3-56	3-26-57 ^b	12-18-57	8- 3-56b	8-19-53	8- 3-56 ^b	8-19-53
	State well :	number			12S/1W-20L1	3041	3081	31#1						32B1	32E1		

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

	: Per	. Na			55	;	58	УК	ρ ₄ 2	33	37	×	f ⁴ 3	37	38	煮	∄
	80	Caco ₃ ,			275	2H2	208	210	378	313	252	293	394	564	298	163	175
	: Total : Total : dis- : hardne :solved : as	: solide,:			969	1	989	650	270	539	501	525	801	200	089	323	381
	ф	: wdd			0.10	1	0.20	0.03	0°05	0°05	0.15	\$0°0	0.12	0.20	0.03	0°03	90.00
	[h ₄	udd			9°0	1	ή*0	2.0	ቱ°0	0.1	0.2	† *0	0.3	0.1	9.0	0.2	0°5
	•• ••	NO ₃			0.37	ili	0.19	0.27	28 0.46	S. E.	0.20	13	37 0.59	0.05	0.10	2 0.0 4	010
	۱¤	CJ			20th 5-75	18t 5-19	174	170	197 5.56	2.03	84 2.37	85 2,40	150	88 2.48	88 2.48	1.24	1.97
	lon millio	so _t			1.31	1	52 1.08	0.73	1.89	3.80	59 1.22	62	2.11	62 1.29	1.33	39 0.82	26 0°.54
	parts per million equivalents per million	НСО ₃	(penul	(po	285 4.68	14,00	3.80	1,00 1,00	4.92	326	#;; "	315	412	293	25 85 85 85 85 85 85 85 85 85 85 85 85 85	<u>169</u> 2.77	3.88
	parts equiva	89	T (conti	o ontime	0.24	1	00	00	00	00	00	00	00	စ် စ	00	00	00
	ts in	×	OGIC UNI	Basin (2°00	ılı	3.07	0.04	0.03	0.08	2 0.04	0.05	0.05	0.08	00.20	2 0.0 0	0.00
2	neral constituents in	Na	CENTRAL HYDROLOGIC UNIT (continued)	San Pasqual Basin (continued)	155	1 1	134 5.83	125 5.43	125	3.09	20 3.03	3.28	340	3.17	3.74	33	6 ^t 2°.78
	ineral co	Mg	CENTRA	San	2.71	1	24 1.97	25 2.05	3.62	34 2.79	26 2.12	<u>35</u> 2.88	誓	2.54	2.95	13	1.73
	M	GB B			2.79	1/1	2.20	42 2.15	73 3°4 3°4	3.49	58 2.92	60 2.99	20 3.49	2.75	3.00	1:3	35
	·· ·· ··				8.2	7.9	7.2	7.5	7°4	7.2	7.1	7.2	8.0	7.4	7.2	7.5	7.7
	ECz106	25°C :			1,042	1,005	1,000	1,060	1,182	885	110	813	1,220	800	1,010	1480	628
	:Temper -: ature :	: oF :			70	89	65	1 79	9	49	1	99	89	89	99	19	68
	Date	sempled :			8-25-54	8- 4-55	8- 3-56b	3-26-57 ^b	8-24-54	3-25-57	8-19-53°	8-25-54	8- 4-55	8- 3-56 ^b	3-26-57 ^b	3-26-57	3-25-57
	State well :				12S/1W-32G1 {				33£1	3431	3461					35B2	3502

MINERAL ANALYSES OF CROUND WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

								(anii ta in a)										
State well	Date	:Temper -: ECx10 ⁵ : ature : ECx10 ⁵ : when : at	ECx106	FZ.	E	ineral o	Mineral constituents in	ıts în	parts equival	parts per million equivalents per million	on millio	Į s		(Ec.	pa.	: Total : Total : dis- : hardne : solved : as	88	Per :
mmber	sampled	: Sempled:	25°C :		සිට	Mg.	Na		600	HCO3	SOL	C1	NO3	wdd	=	: solide,:	caco,	. Na
						CENTR	CENTRAL HYDROLOGIC UNIT (continued)	COGIC UNI	T (cont	(penu)								
						Sa	San Pasquel	Basin	(continued)	(pe								
12S/1W-35H1	8-19-53°	;	9641	7.1	1.4	16 1 1 31	1.74	0.05	00	2.82	47 0°97	1.23	0.32	0.2	0.15	283	162	35
35H2	8-19-53	i	529	7.0	41 2.07	18	1.81	0.05	00	179 2.94	47 0.97	1.32	10	0°2	0°30	342	178	33
	8-25-54	61	094	8.0	1.70	20	1.74	2 0.0 0.0	00	2.80	43 0.89	1.16	0.10	ካ*0	0	310	191	赤
	8- 4-55	99	694	4°8	1.95	1.48	1.78	0.05	17 0.56	134 2.20	32 0.81	1.4	6 0.10	0.3	0	320	171	*
3513	3-26-57	89	916	7.0	2.94	3.62	3.26	0.08	00	265 4.35	1.29	3.05	1.07	0.3	0°03	199	325	33
3661	3-26-57	61	591	7.1	41 2.05	22 1.81	1:%	0.05	00	<u>169</u> 2.77	1.02	<u>69</u> 1.95	0.01	0.2	0.03	37.9	194	3
138/1W- 3E1	3-26-57	69	1,107	7.5	3.54	43 3.53	109	0.05	00	415	27,148	3.30	0.05	0.5	0°05	673	355	01
5A1	3-26-57	58	2,583	7.3	12 ⁴ 6.19	<u>76</u> 6.25	330 14.36	0.06	00	587 9.63	3.06	12.80	0.87	0.5	0.15	1,589	622	23
13S/2W- 1J1	4- 5-57 ^b	89	1,310	7.1	4.75	3.69	102 4.43	0.06	00	4.50	208 4-33	152 4.28	010	10°7	0	998	H22	ま
IRI	7-10-53	1	853	7.7	83	2.55	3.26	0.12	00	264 4.32	140 2.91	23	0.03	0.8	0.10	287	334	33
							COASTAL	COASTAL HYDROLOGIC UNIT	HIC UNIT									
							San D	San Dieguito Basin	Besin									
138/3W-28N1	3-26-57	89	1,222	7.9	68 3°40	23.75	103	0.04	00	256 4°20	1.05	201 5.65	90.08	e**	60°0	849	307	142
32R1	8- 2-55	89	2,560	2.6	358 8°40	6.90	3.00	0,08	00	5.30	169 9°77	13.30	₩ 10.0	1.7	ο°45	1,773	094	¥

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

			:															
** ** **	Date	: Temper -: ature :	ECX106	语	•• •• ••	Mineral o	neral constituents in	ts in	parts p	parts per million equivalents per million	on million		00 no	βs _e		: Total : Total : dis- : hardne : solved : as	: Total : :hardness: Per : as	Per
	sampled	sampled:	25°C :	1	Ca	. Mg	Na	×	600	HC03	SO ₁	CJ :	N03 :	add	mdd :		0	Na
						COAST	COASTAL HYDROLOGIC UNIT (continued)	ogic uni	F (conti	(penu								
						San	San Dieguito Basin		(continued)	q)								
138/3W-33B1	3-27-57	1 0	1,150	7.9	4.45	2.75	3.59	0.08	00	277 4.55	111	176	2 0.04	0.1	0.05	678	360	33
3306	3-26-57	0	1,397	7.3	4.55	3.95	131	0.03	00	214 3.50	223 4.64	206	2 0.04	0.2	ů ů	897	425	011
33F2	3-26-57	99	1,900	7.4	340	5.60	136	0.03	00	223 3.65	210 4.38	372	3 0.05	0.2	0 8	1,190	630	32
3316	8-24-540	72	1,660	7.4	5.85	4.32	13th 5.82	0.09	00	267	212	267	10.07	0.1	0.95	1,086	508	3%
	3-27-57	99	1,545	7.7	88 1,40	3.70	163	5 00.14	00	387 6.35	106	5.40	0.11	E*0	0.13	889	405	941
3301	3-27-57	99	2,050	7.3	89 4°45	5.75	178	5.00	00	3.10	3.71	11.60	0.05	0.3	0.18	1,195	570	र्भ
1945/34- 4PI	3-27-57 ^b	99	5,165	7.4	28.75	2000	336	0.06	• [•	342	651 13.55	33.24	20.32	L°0	0.24	3,410	1,904	28
13	8-24-540	72	14,380	8.2	39	3.43	33.50	26	E E	573	24th 25.07	879 24.80	0.10	0.8	0.80	2,384	270	85
	8- 2-55	69	3,730	7.9	2,30	3.36	33.20	26 0.57	00	9.95	4.88	872 24.60	00.10	6.0	0.92	2,272	283	₹
	7-31-56b	70	3,860	7.4	137 6.85	7.38	24.61	34 0.87	00	7.28	365	870 24.51	010	0.2	09.0	2,328	711	62
	3-26-57	₹9	2,160	7.2	136	5.55	203 8.85	0.11	00	412 6.75	360	26 ⁴ 7.45	30.04	0.3	0.23	1,351	617	β
5K2	3-26-57	99	000 %	7.6	7.05	36 7.05	19.00	25 0.65	00	6040	32	864 24.35	50.08	† •°0	0.35	2,350	705	18
K	3-26-57	99	2,435	7.4	1.00	3.25	394 17.12	6 0.15	00	3.05	2.99	35.90	30	0.8	0.38	1,295	212	80

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

		:Temper-:								1000			*			: Total : Total	Total	
State well :	Date	: ature :	124	语		Mineral o	neral constituents in	ts in	edulva.	parts per miliion equivalents per million	on million	le		·· ··	æ	: dis- :h		: Per
number	sampled	: sampled:	~		CB	. Mg	ay.	×	C03	HC03	; tos	C1 ;	NO3	: wdd	wdd	solids;	CaCO 3,	NB.
						COAST	COASTAL HYDROLOGIC UNIT (continued)	OGIC UNI	T (cont	(penu								
						San	San Dieguito Basin (continued)	Basin (oontinu	(p)								
149 -ME/ShI	8-24-548	え	3,180	8.2	8t t-18	4.67	1495 21.50	25 0.65	00	340 5.57	226 4.71	20.65	8	0.5	0.89	1,885	1 44 2	2
	8- 2-55	69	3,280	7.7	98	52 4.87	23.80	25 0.64	00	342 5.60	242 5.05	812 22.90	0.12	1.0	0.70	1,986	1488	22
	7-31-56 ^b	69	5,015	4°8	146 7.30	84.9 6.83	32.83	40 1.02	1.60	259 4.24	426 8.88	34.14	0.03	ħ°0	0.80	2,9मम	709	69
6P2	3-26-57	99	3,360	7°4	100	1.60	513 22.30	0.23	00	336	246 5°13	27.5	0.11	9°0	g Q	1,960	1480	69
702	10-16-53	D 9	8,130	7.6	# 150 1.69	9.86	1,760 76.56	25 0.63	00	1, 149 18,84	37.2	2,290	0.14	9°0	1.56	5,215	121	志
703	8~20~540	89	14,060	7.5	2.71	3.68	697 30.30	24 0.62	00	412 6.76	363 7.56	829 23.40	6.14	6.0	2.50	2,323	319	81
	7-31-56b	69	3,700	7.6	126	6.73	593 25.80	3 0.65	• •	3.64	7.29	1,001	0.02	0.3	0.90	2,628	652	65
704	8-12-54	22	5,208	7.8	161	6.40	1,025	30	00	388	621	1,410 39.80	0.13	1.4	1.08	3,685	726	75
	8- 2-55	89	5,250	2.6	120	5.30	1,005	25	00	257 5.85	608	1,291 36.40	0.13	1.4	1,32	3,346	550	79
	7-31-56	70	4,200	8.3	89	3.30	810 35.20	18	00	326	508 10.58	27.30	4 0.07	3.2	1.05	2,650	377	83
	3-26-57	99	2,960	7.5	43	3.85	26.00	5.0	00	<u>269</u> 6.05	291	590	5 0.03	1.0	0.95	1,747	195	87
7.5.1	3-26-57	B E	5,310	7.5	3.65	61	%8 42.10	0.20	00	665	272 2.66	1,262 35.60	13	8.0	1.25	3,081	435	8
752	3-26-57	•	3,300	7.5	1 ¹ 1 ⁴ 1	2,25	596 25.90	90.16	00	405 6.65	269	644 18.15	5.08	1.2	0.08	1,872	222	35

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

: Total : :hardness: Per				791 144	311 76	245 45	69 045	426 68	69 499	90 28	75 53	65 55	00	20	54	376 80
	ະ ເຄ					8	ις.	≠		1,190	8,275	7,465	7,700	7,820	7,875	Š
: Total : die-	solids:			1,750	1,810	588	2,248	1,676	2,350	3,665	22,513	20,140	1	1	;	2,335
	udd :			0.20	0.34	0.10	0.88	%**	0.68	}	17.70	12.80	1	;	;	1,02
ps.,	udd			9*0	2.0	9*0	1.4	0.8	1.0	8.0	0.8	0.3	1	;	:	ا م
•• •• ••	NO 3			010	010	0.0	0.91	50	26 0.42	90.14	18	010	ili	1 1	3 1	36
	ເມ			455 12.82	615 17.32	3.4	858 24.20	493 13.89	21.69	1,397 39.40	11,630	310.005	317.46	318.31	307.04	1,063
on million	SO ₁			478 9.96	310	1:13	316	262 5.46	362 7.54	230	1,136	1,162 24.19	1 1	11:	i	180
parts per million equivalents per million	. HC03	(penul	(pe	2% 4.85	317 5.20	223 3.65	351 5.75	130	604	143 2.35	1.55	1,00	6.80 0.80	t‡ 0•72	00.80	गुरु
parts p	, co ₃	T (cont	continue	00	00	00	00	00	00	00	00	00	00	00	12.2	C
s In	×	OGIC UNI	Basin (6 0.15	30.08	2 0.04	39	6.16	0.24	0.31	10	1.20	1 1	: :		30
Mineral constituents in	Ne.	COASTAL HYDROLOGIC UNIT (continued)	San Dieguito Basin (continued)	<u>285</u> 12.39	22.00	3.%	600	432 18.78	<u>533</u> 23.17	218	186.00	1, 232 184,00	; :	: :	1	740
eral con	훮	COASTA	San	60 4.92	43	20 1.65	<u>65</u> 5-31	3.52	67 5.49	170	130	242 19.90	1	1 1	: :	32
M1n	80			218	2.70	<u>65</u> 3.25	122	100	156 7.80	197 9.85	3,102	2,593	: :	1 1	: 8	86
 Fa	'			7.4	7.4	7.3	8.0	8.0	8.2	7.3	8.3	7.0	7.9	7.3	η°8	7.4
ECx106 :	``			2,650	2,960	915	3,670	2,500	3,715	5,570	31,200	30,629	32,485	30,860	28,680	3,759
Temper : ECx106 : when : at	: Sampled:			:	1	99	ł	ま	!	1	1 9	69	1	72	70	70
Date	Ð			3-26-57 ^b	3-26-57 ^b	3-26-57 ^b	8- 2-55	7-31-56 ^b	3-25-57 ^b	3-25-57	3-25-57	7-16-57 ^b	8-15-57 ^b	9-16-57 ^b	10-21-57 ^b	8-13-54
State well :	number			145/3W- 7K1	TAAL	841	14S/4W- 1P1			1P2	11,72					121

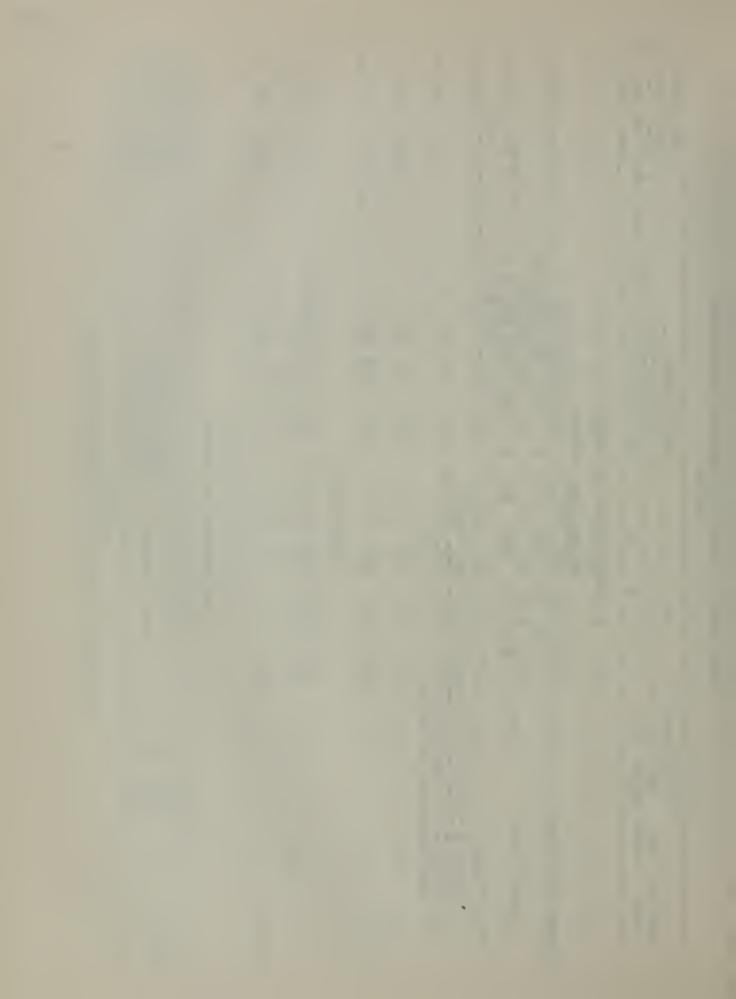
MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

:Temper -: EXIO6 :	ECx106 : : Mineral conetituents in					arts per million nuivalents per million	1111on per million	l e				: Total	: Total	Per
Date : when : at : pH : equivalents p sampled :sampled: 25°C : : Ca : Mg : Na : K : CO ₃ : HCO ₃	at : pH : 25°C : Ca : Mg : Na : K :	. Mg : Na : K :	Na K	ж :	ж :	co ₃ HCo ₃	m m	SO _t	: C1 : NO ₃		F : B ppm : ppm	solved:	ceco ₃ ,	oent Na
COASTAL HYDROLOGIC UNIT (continued)	COASTAL HYDROLOGIC UNIT (continued)	COASTAL HYDROLOGIC UNIT (continued)	COASTAL HYDROLOGIC UNIT (continued)	. HYDROLOGIC UNIT (continued)	GIC UNIT (continued)	(continued)								
Sen Dieguito Basin (continued)	San Dieguito Basin (continued)	San Dieguito Basin (continued)	San Dieguito Basin (continued)	Meguito Basin (continued)	Basin (continued)	ntinued)								
8- 2-55 68 3,460 7.5 $\frac{28}{1.40}$ $\frac{28}{2.30}$ $\frac{26}{30.70}$ $\frac{33}{0.84}$ $\frac{0}{0}$ $\frac{375}{6.15}$	$7.5 \frac{28}{1.40} \frac{28}{2.30} \frac{706}{30.70} \frac{33}{0.84} \frac{0}{0}$	28 706 33 0 2.30 30.70 0.84 0	706 33 0 30.70 0.84 0	33 ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° °	00		III	5.03	840 5 23.70 0.08	1*1	t 1.23	2,066	185	87
$3-27-57$ $20,500$ 7.2 $\frac{319}{15,90}$ $\frac{488}{40,10}$ $\frac{2,427}{149,00}$ $\frac{211}{5,40}$ 0 $\frac{329}{5,40}$	7.2 $\frac{19}{15.90}$ $\frac{488}{40.10}$ $\frac{3.427}{149.00}$ $\frac{211}{5.40}$ $\frac{0}{0}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\frac{3.427}{149.00} \frac{211}{5.40} \frac{0}{0}$	211 0	00		10	206 18.87	6,489 th 7183.00 0.07	5 0.3	3 1.60	13,045	330	17
Remainder of Unit	Remainder of Unit	Remainder of Unit	Remainder of Unit	Remainder of Unit	der of Unit	쓃								
$3-27-57^{b}$ $3,900$ 7-7 $\frac{364}{18.20}$ $\frac{41}{3.36}$ $\frac{456}{19.83}$ $\frac{6}{0.14}$ $\frac{0}{0}$ $\frac{31}{0.50}$	7.7 $\frac{364}{18.20}$ $\frac{41}{3.36}$ $\frac{456}{19.83}$ $\frac{6}{0.14}$ $\frac{0}{0}$	41 456 6 0 3.36 19.83 6.14 0	19.83 6 0 19.83 0.14 0	6.14 0	00		10	1,300	8 12.96 0	8.0	0.45	2,700	1,078	8 1
$3-12-57^{\text{b}}$ 69 2,395 7.5 $\frac{83}{4.15}$ $\frac{48}{3.95}$ $\frac{34}{14.52}$ $\frac{4}{0.10}$ $\frac{0}{0}$ $\frac{256}{4.20}$	$7.5 \frac{83}{4.15} \frac{48}{3.95} \frac{334}{14.52} \frac{4}{0.10} \frac{0}{0}$	$\frac{83}{4.15} \frac{48}{3.95} \frac{334}{14.52} \frac{4}{0.10} \frac{0}{0}$	334 t 0 14.52 0.10 0	0,10 0	00		10	2.40	575 16.20 0	1.0	0.18	1,400	405	₹9
$3-26-57$ $1,128$ 7.6 $\frac{60}{3.00}$ $\frac{35}{2.90}$ $\frac{109}{4.73}$ $\frac{1r}{1r}$ $\frac{0}{0}$ $\frac{244}{4.00}$	$7.6 \frac{60}{3.00} \frac{35}{2.90} \frac{109}{4.73} \frac{\Gamma_{\mathbf{r}}}{\Gamma_{\mathbf{r}}} \frac{0}{0}$	35 109 Tr 0	109 Tr 0	00	00		10	1.42	177 15 5.00 0.24	Q 0.3	-	637	288	#
$3-26-57$ $1,485$ 7.8 $\frac{90}{4.50}$ $\frac{43}{3.50}$ $\frac{134}{5.85}$ $\frac{7}{0.19}$ $\frac{0}{0}$ $\frac{180}{2.95}$	$7.8 \frac{90}{4.50} \frac{43}{3.50} \frac{134}{5.85} \frac{7}{0.19} \frac{0}{0}$	$\frac{43}{3.50}$ $\frac{134}{5.85}$ $\frac{7}{0.19}$ $\frac{0}{0}$	134 7 0 0 5.85 0.19 0	2000	00		Ιſ	7.07	151 th	9°0 2	5 0.13	930	001	42
$1-24-57$ $11,150$ 7.7 $\frac{1,130}{56,40}$ $\frac{372}{30.60}$ $\frac{1,218}{57,30}$ $\frac{10}{0.25}$ $\frac{0}{0}$ $\frac{197}{3.23}$	7.7 $\frac{1,130}{56.40}$ $\frac{372}{30.60}$ $\frac{1,318}{57.30}$ $\frac{10}{0.25}$ $\frac{0}{0}$	$\frac{372}{30.60} \frac{1.318}{57.30} \frac{10}{0.25} \frac{0}{0}$	$\frac{1.318}{57.30} \frac{10}{0.25} \frac{0}{0}$	10 0.25 0	00		Iω	39.66	\$ 3,599 9 101.50 0.14	1.1	0.75	9,254	4,350	9
$3-27-57^{\text{b}}$ 61 10,080 7.3 $\frac{584}{29.20}$ $\frac{443}{36.31}$ $\frac{767}{33.34}$ $\frac{8}{0.20}$ $\frac{0}{0}$ $\frac{366}{6.00}$	7.3 $\frac{584}{29.20}$ $\frac{443}{36.31}$ $\frac{767}{33.34}$ $\frac{8}{0.20}$ $\frac{0}{0}$	443 767 8 0.20 0	267 8 0 33.34 0.20 0	00000	٥٥		10	1,545 32.19	5 2,140 0 9 60,28 0	1.5	9H°0 5	6,420	3,275	煮
$1-24-57$ 63 $10,660$ 6.9 $\frac{1,202}{60,00}$ $\frac{423}{34,80}$ $\frac{1,006}{43,75}$ $\frac{6}{0,15}$ $\frac{0}{0}$ $\frac{305}{5,00}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	1,23 1,006 6 0 34,80 43,75 0,15 0	1,006 6 43,75 6,15 0	6 0 0	00		10	- 1465 <u>7</u>	2 3,563 5 100,50 0.08	1.0	0 0.25	9,143	04/64	32

MINERAL ANALYSES OF GROUND WATER IN SAN DIEGUITO RIVER WATERSHED® (continued)

: Total : Total : dis- : hardness: Per B :solved : as : cent ppm :sollds,: CaCO3, : Na : npm : npm : npm			,750 795 42	100 998 58
s: wdc			0.09 1,750	0.74 3,100
•• •• •• ••				
F Pow			9°0	9.0
NO ₃			5000	010
5			700 19.71 5.09	25.35
1 on 1111111111111111111111111111111111			226 4°71	710
equivalents per million	thued)	(per	3.46	427 7.00
parts equiva	IT (sont	(continu	00	00
its in	OGEN UN	f Unit	0.25 0	0.08
Mineral constituents in Mineral Maria K	COASTAL HYDROLOGIC UNIT (continued)	Remainder of Unit (continued)	11.87	$\frac{625}{27.17}$
fineral o	COAST	8	5°41	85
85 85			210	260
强			7.1	7.0
ECx106 at 25%			2,770	4,915 7.0
Temper : ECx106 : ature : ECx106 : when : at : i : sampled: 25°C : oF : i : oF : oF			89	ł
Date sampled			3-26-57 ^b	3-27-57 ^b
State well : number :			145/3W- 7P1	1081

Analyses by Department of Water Resources unless otherwise indicated. Analyses by Ferminal Testing Laboratories, Inc., Los Angeles, California. Analyses by Pacific Chemical Consultants, Van Nuys, California. Total dissolved solids by summation. р. ф.



APPENDIX G

APPLICATIONS TO APPROPRIATE WATER
AND
RECENT LITIGATION AFFECTING WATER RIGHTS
IN SAN DIEGUITO RIVER WATERSHED

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APPLICATIONS TO APPROPRIATE WATER AND

RECENT LITIGATION AFFECTING WATER RIGHTS IN SAN DIEGUITO RIVER WATERSHED

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APPENDIX G

WATERSHED
RIVER
DIEGUITO
AN
IN SAN
WATER 1
APPROPRIATE
30
APPLICATIONS

Appli-				Loo	Location	of poin	of point of diversion	versi	E	: Amount :		
ramber	: Dete : filed	: Applicant	Source:	1/4 : 1/4	1/4	Sec- :	Sec- : Town-: : : : : : : : : : tion : ship : Range: ian	Sance	rerid-	:rerid-:applied for:	Purpose :	Status
264	10- 2-16	E. Fletcher	Santa Maria Creck	eg Ø	SE.	11	135.	1W.	S, B,	20 ofs and 6,000 af	Agriculture	Yithdream
28/	1-16-17	E. Fletcher	Santa Tsabel Creek	SH.	NA.	21,	125.	23.	s. E.	30.00 cfs and 11,855 af	Power	Revoked
22,77	1-25-21	E. Pect, et al.	Guejito Greek	. Red	SB.	23	125	in m	S E	6.50 ofs and 624 af	Agriculture	Cancelled
2315	4-20-21	City of Sen Diego	San Dieguito River	នូ	MW.	18	138	21.	เก	37,700 af	Muntotpal	Certificate
2865	6- 5-22	G. T. Simps on	Sarta Beria Greek	Sg.	SE.	ជជ	138.	1W.	S.B.)	1.59 cfs and 150 cf	Agriculture	Revek ed
3000	8-21-22	G. T. Simpson	Sente Maria Creek	S.II.	.an	п	135	78.	S.	1.75 ofs and 200 af	Agriculture	Withdrewn
2001	8-21-22	G. T. Simpson	Santa Maria Creek	. .	ĕ.	11	138.	IV.	S.B.	1.75 cfs and 200 a£	Power	Withdrawn
3359	t -16-2 3	R. Y. Hollend	Unnumed springs tributary to Haffield Greek	SN.	S:	60	138.	2E.	S. B.	0.19 cfs	Agriculture	Revoked
<i>12</i> 11 ₁	7-31-24	City of San Diego	Tributeries to Santa Ysebel Greek	SW.	SW.	17	12S.	सं सं	S.B.	30 cfs and 60,000 af	Municipal	Cancelled
4202	9-10-54	Ramona Irrigation District	Hatfield Creek	SE.	NE.	13	135.	12.	S.B.	3,500 af	Agriculture	Cancelled
4203	9-10-54	Ramora Irrigation District	Sante Ysabel Creek				125.	्व चि	S.B.	5,000 af	Agriculture	Canoelled
14.943	11-28-24	George W. Wood, et al.	Underground water San Dieguito River	NW.	- E	35	125.	1W.	S. E.	0.75 ofs (11cense)	Agrieulture	License
4363	12-12-24	Ray Trusell	Underground water Santa Tsabel Greek	SIE.	HE.	35	125.	18.	S. G.	0.25 cfs	Agriculture	Withdrewn
4929	2-23-26	Le Mese Lemon Grovers and Spring Valloy Irrigation District	Serta Tsabel Greek	Lot 5		19	125.	<u>ب</u>	S, E	50 efs and 18,000 af	Agriculture	Cancelled
5185	9- 2-25	Le Mesa Lemon Grovers and Spring Valley Irrigation District	Starta Yschel Greek:	Lot 5		19	125.	i i	S, E,	50 cfs and 18,000 af	Municipal	Cancelled

APPLICATIONS TO APPROPRIATE WATER IN SAN DIEGUITO RIVER WATERSHED[®] (continued)

40 00 00	Dato :	Applicent	Source	. 1/4 . 1/4	s 1/4 :	Location of point of diversion : Sen : Town : : MM . 1/4 : tion : ship :Renge:	Towners	Town-: "Meri	Merid-	Meric-tapplied for,	. esodind .	Status	
7=16=27	_	A. M. and Fannie I. Neal	Unnamed spring tributary to unnamed creek, tributary to San Dieguito River	R	N.W.	50	138,	1W.	S. B.	0.02 cfs	Domestin	Revoked	
9-20-28	«C	Laura Á. Yarnell	Unnamed spring tributary to unnamed creek, tributary to San Dieguito River	SE.	SW.	28	138. 138.	IW.	S.B.)	S.B.) 0.01 ofs	Agriculture	Cancelled	
11-12-30	30	La Mesa Lemon Growers and Spring Valley Irrigation District	Santa Ysabel Creek	Lot	2	19	125.	हू इ	S. B.	50 cfs and 18,000 af	Munioipal	Withdrawn	
11-12-30	30	La Mesa Lemon Growers and Spring Valley Irrigation District	Santa Ysabel Creek	Lot	2	19	12S.	3E.	SoBe	50 cfs and 18,000 af	Agriculture	Withdrawn	
12-30-32	.32	James K. Banes	Unnamed oreek tributary to San Dieguito River	NE.	S. B.	18	135°	1W.	S.B.	5 af	Agriculture	Cancelled	
4-5-33	m	James K. Banes	Unnamed creek tributary to San Dieguito River	NE	S. S	18	13S。	1W.	S S	0.02 cfs and 9.7 af	Agriculture	Cancelled	
8-7-36	10	Owen R. Brown	Unnamed creek tributary to Santa Ysabel Creek		ež.	17	12 S.	1E。	S. B.	5.00 ofs	Agriculture	Cancelled	
8-31-36	36	Melvin Moore	Unnamed oreek tributary to Senta Ysabel Creek	NE.	SW。	20	12S.	1E。	s m m	3.00 cfs and 50 af	Agriculture	Canoelled	
4-13-37	37	Nina Nelson	Unnamed oreek tributary to Santa Ysabel Greek	NE	SW。	50	12S.	1E.	S. B.	3.00 ofs and 48 af	Ромег	Revoked	
4-13-37	37	Nina Nelson	Unnamed creek tributary to Santa Ysabel Greek	NE.	SW。	50	12S.	1E.	S. B.	3.00 ofs and 48 af	Mining	Revoked	
9-29-41	4	Santa Fe Irrigation District	San Dieguito River	NE.	SW.	27	135.	34.	S.B.	4.00 cfs	Agriculture	Cancelled	
6-21-43	643	Guy B. Woodward, reassigned Richard D. Woodward	Unnamed spring tributary to Clevenger Canyon, tributary to Santa Ysabel Creek	SE.	SE	#	135.	1E.	s m m	9,360 gpd (11cense)	Agri culture	License	

APHAICATIONS TO ANYBOPRIATE WATER IN SAT DISCUSSO RIVER WATERFIELD (continued)

Status	Permit	Osnaelled	Cancelled	Carcelled	Permit	Ferrit	Permit	Cuncelled	Revoked	Permit	Cancelled	1 purod.	
Purpose	Agriculture	Agriculturs	Agriculture	Agriculture	Municipal	Funicite.1	Municipal	Agriculture	Agriculture	Agriculturo	Azriculture	Agriculture	Municipal
ior : Amount :	0,30 cfs	0.02 ofs and 5 af	2,500 af	30,000 af	50 cfs and 50,000 af	130,000 af	230,000 af	5 af	91 af	20 e.f	0.07 cfs and 2.7 af	0.60 cfs and 12 af	0.50 afs
or nerid- ian	cd at	œ. vi	m vs	S.E.	S, <u></u>	S.B.	ស្ល	S. E.	ន ន	Seg	ള്ള ഗൂ	នាំ	ಜ್ಜಿಜ
diversion : neric :Range: ien	118	200	N.	*	2E.	E.	27.7.	2 ¹ / ₂	W.	isi erri	23.	143.	E
nt of o Town-	12S.	125.	135.	138,	125.	125.	138.	12S.	145,	125.	138.	14S.	138.
Location of point of : . sec- four- : 1/4 : tion : chip	£	%	22	22	21	27	18	3,4	8	%	7	r-4	15
Location : : : : : : : : : : : : : : : : : : :		[2] Z	in in	SE SE	· EX	ig E	N. P. C.	SW.	SS	izi Z	: : :	<u>در</u>	SW.
Lo 1/4	, so	an An	See See	SE.	ري. د	SE	SE.	IW.	SW.	NH.	N T		N.
Source	Unnamed spring tributery to unnamed creek, tributary to San Dieruito River	Scepare tributary to unnamed creek tribu- tary to San Dieguito River	Sen Dieguito River	San Dieguito River	Santa Ysabel Creck	Santa Ysabol Greek	San Dieguito River	Unnamed creck tributery to San Dieguite Hiver	La Zanja Creek	Sarda Maria Creek	Hatfield Greek	Unnamed creek tributary to San Diagnite River	Senta Maria Creek
:	3 E. S. end Mildred E. Dizon, reassigned Melvin L. and Emma Brazion	6-22-45 Kenneth A. Kestover	7-15-46 Sen Dieguito Irrication District	San Diequito Irrigation District	City of San Diego	12-12-16 City of San Diego	12-12-46 City of San Diego	7 Robert N. McLeen	10- 7-47 Clement C. Floorsch	3 N. C. Scherke	3 James B. Marnock	9-26-50 L. G. and Lucic R. Licnhard, roassigned L. G. Licnhard	6 C. E. and Edra P. Juiney
Date filed	8-5-43	6-22-45	7-15-46	94-51-8	12-12-46	12-12-16	12-12-146	6-19-47	10-7-01	84-6-3	11- 1-48	9-26-50	12=26-56
Afpli- : eation : number :		11078	11458	11522	11658	11658	11658	11%	12121	12636	12772	139(6	17406

a. From records of State dater Rights Beard.

FINDINGS OF FACT AND CONCLUSIONS OF LAW

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA

IN AND FOR THE COUNTY OF SAN DIEGO

STANLEY TRUSSELL, et al.,	>
Plaintiffs,) No. 205,488
vs.) FINDINGS OF FACT AND
THE CITY OF SAN DIEGO, a Municipal Corporation,	CONCLUSIONS OF LAW
Defendant.)))

The above entitled action coming on regularly for hearing the 20th day of August, 1957, before the Honorable Arthur L. Mundo presiding and SWING, SCHARNIKOW & STANIFORTH by Phil D. Swing and C.H. Scharnikow appearing for Plaintiffs, and AARON W. REESE and AIAN M. FIRESTONE, Deputy City Attorneys appearing for the Defendant, and oral testimony and documentary evidence having been introduced on that day and on succeeding days to which said case was regularly continued and the taking of evidence having finally been completed on the 14th day of October, 1957, and said cause having been orally argued by respective counsel on the 17th, 18th and 21st of October, 1957, and written briefs filed, the case was submitted and the court being fully informed and advised in the premises, and having considered all matters in relation thereto, now makes its Findings of Fact and Conclusions of Law, as follows:

FINDINGS OF FACT

I.

The Plaintiffs were and are, respectively, the owners of the several

parcels of land described and set out in the First Cause of Action of the Complaint herein as belonging to them, except that Plaintiffs Harold W. Pfeiffer and Helen L. Pfeiffer on June 21, 1956 conveyed their lands to Defendant THE CITY OF SAN DIEGO. Plaintiffs lands are situated in what is commonly known as the East San Pasqual Valley, San Diego County, State of California.

II.

San Dieguito River, known above its confluence with the Santa Maria Creek as Santa Ysabel Greek, has a watershed of 347 square miles. The river is also known as the San Bernardo River. It rises on the slope of Volcan Mountain at an elevation exceeding 5,500 feet and flows through a series of canyons and narrow valleys for some 53 miles, entering the Pacific Ocean a mile north of Del Mar. Principal tributaries are Witch Creek, Black Canyon, Temescal, Roden Canyon and Guejito Creek and Santa Maria Creek, all but the first and last named of which enter from the north. There are two principal valleys through which the river flows, the San Pasqual Valley and the San Dieguito Valley, Sutherland Dam is located on the Santa Ysabel Creek about ? miles northeast of Ramona at Streambed elevation of about 1,900 feet. The river, together with the rainfall on the valley floor, supplies the water in the underground basin of these valleys. Except in the upper reaches, the surface flow of the river is not perennial but flows irregularly from negligible discharge in some summer seasons to occasional torrential floods during protracted winter storms.

Through said East San Pasqual Valley the subsurface flow of said Creek percolates through the sands and gravels which underlie Plaintiffs' lands, and is the principal source of the underground waters found in that portion of the San Pasqual Basin over which Plaintiffs' said lands are located.

III.

As owners of said lands, each of said Plaintiffs is the owner of riparian rights in and to the waters of the Santa Ysabel Creek and of overlying rights in and to the underground waters of the San Pasqual Basin over which their said respective tracts of land lie. Also the Plaintiffs (except the Cooks) each own a share of the appropriative rights in and to the waters of the Santa Ysabel Creek which were initiated in the year 1876 and perfected and put to beneficial use by the predecessors in interest of said Plaintiffs long prior to the year 1913, and have ever since been exercised, enjoyed and put to beneficial use by them and by Plaintiffs on their said lands respectively owned by them, (except the Cooks), to the full extent of their requirements, as and when the water was available in said stream at their diversion works at the head of the said San Pasqual Valley which said water they have taken and used. In recent years plaintiffs have not, by their said diversion works, ditch and pipe lines diverted, transported and used on their respective lands at any time, quantities in excess of 12 cubic feet per second.

IV.

The City of San Diego in 1952 commenced building Sutherland Dam under its State permit #7942, issued to it June 20, 1950, and completed its construction, closing the downstream outlet on December 30, 1953, and thereafter has stored and retained all water originating in the watershed above said dam, to wit: 7,604 acre-feet from January 1, 1954 to June 30, 1957 of which 4,757 acre-feet was the inflow for the year 1953-1954; 733 acre-feet in 1954-1955, and 910 acre-feet was in 1955-1956. The appropriation of water by the City of San Diego in Sutherland Dam, and the subsequent distribution and sale of a portion thereof was and is a public use. That since

the completion of said dam there has been no surplus waters in said creek available to Defendant to store behind said dam, but all of said water so stored by it was required by Plaintiffs to supply their reasonable needs and uses on their said lands.

V.

The withholding by the Defendant, The City of San Diego, of all the water of Santa Ysabel Creek originating above Sutherland Dam resulting in less of stream flow, both in the quantities and in the extent of time and duration of the flow which otherwise would have reached San Pasqual Valley and Plaintiffs said lands causing the water plane or water table beneath Plaintiffs lands to fall below the root systems of their trees, orchard and alfalfa, necessitating Plaintiffs having to irrigate their said trees, orchards and alfalfa more frequently than they otherwise would have had to do, thereby increasing their labor costs for irrigators and power costs for pumping irrigation water from their wells. That the water from their wells was of poorer quality than the surface flow of the Creek which they diverted at the head of the Valley and delivered to Plaintiffs' said lands for use thereon (except the lands of Plaintiffs Cook) in this, that the Creek flow was warmer and carried silt which fertilized their lands. Also the water plane or water table fell so low that Plaintiffs were unable to obtain their requirements from their respective wells without the expenditure of substantial sums of money by them for new wells and new equipment.

VI.

The static water level in Plaintiffs, wells went down from approximately 10 feet below the ground surface before the construction of Sutherland Dam to some 44 feet after the dam was completed. In 1931, an

unusually dry year, the static water level went down to 20 feet. In 1952, an unusually wet year, the level went up to 10 feet. An average range of the static water level in Plaintiffs' wells before Sutherland Dam, was from 12 feet to 20 feet below the ground surface, which range of static water levels is required for Plaintiffs to farm their lands and operate their wells in the manner they were accustomed to do before Sutherland was put in operation.

VII.

The court finds that Plaintiffs have used good judgment as farmers in handling their several operations to obtain water and to produce their crops and there has been no unreasonable method of use or unreasonable method of diversion of water by Plaintiffs or any of them, nor has there been any waste of water by any of them.

VIII.

The Court finds that the losses incurred, expenditures made and damages suffered by Plaintiffs as alleged and claimed by them, were actually incurred, made and suffered by them but that only 50% thereof were caused by and the direct and proximate result of Defendant City's construction and operation of Sutherland Dam and the withholding back of it of the waters of Santa Ysabel Creek originating in the watershed above it; the other 50% the Court finds was the result of other causes, the principal one being the current severe and protracted drought.

IX.

The Plaintiffs Stanley Trussell and Lucille M. Trussell in addition to being the owners in fee of the real property described in Sub-division (a) of Paragraph X of the Complaint were also, during the years 1954, 1955 and 1956, the lessees and entitled to possession and in the

actual possession, occupation and use of that certain real property owned by the Plaintiff May Rhodes Trussell, and described in Subdivision (c) of said Paragraph X.

Said Plaintiffs Stanley Trussell and Lucille M. Trussell were also, during the years 1954, 1955 and 1956, the lessees and entitled to possession and in actual possession, occupation and use of the real property owned by Plaintiffs Erwin C. Georgeson and Lydia C. Georgeson described in Subdivision (j) of said Paragraph X as being in Section 35, Township 12 South, Range 1 West, S. B. B. & M.

The Plaintiffs Stanley Trussell and Lucille M. Trussell were also, during the years 1954 and 1955, the lessees of 10 acres of the real property owned by the Plaintiffs Rebecca F. Judson Dyer, Fred A. Dyer and Bernice J. Judson Morrisey described in Subdivision (h) of Paragraph X, and for the year 1956 were the lessees of the entire 17 acres described in said Subdivision (h), and entitled to the possession and in actual possession, occupation and use of said property under their said leases.

Plaintiffs Frank E. Judson and Velda C. Judson in addition to being the owners in fee of the real property described in Subdivision (e) of Paragraph X of the Complaint, were also during the years 1954, 1955 and 1956 the lessees and entitled to the possession and actually in the possession, occupancy, and use of the real property owned by the Plaintiff Alice N. Judson Suhrie described in Subdivision (f) of said Paragraph X.

X.

Applying the basic principles set out and adopted in the Finding
VIII to the individual items of damages claimed and proven to have been
suffered by the several Plaintiffs, the Court now finds that the Plaintiffs,
respectively, incurred losses, made expenditures and suffered damages

as the direct and proximate result of the Defendant's said acts, as

as one and promine	The state of the s
follows:	
A. Damages suffe	ered by Stanley Trussell and Lucille M. Trussell:
l. By Plaint	tiffs Stanley Trussell and Lucille M. Trussell,
as owners of the land descr	sibed in Subdivision (a) of Paragraph X of the
Complaints	
(a) For t	the year 1954:
	For increased power and labor costs \$160.00 Decreased crop production
	or a total of
(b) For t	the year 1955:
I	For increased power and labor costs \$ 240.00 Decreased crop production
	or a total of \$1,736.00
(c) For t	the year 1956:
I	For increased power and labor costs \$ 420.00 Decreased crop production 1,050.00 For additional water facilities 2,180.70
	or a total of
2. By Plaint	tiffs Stanley Trussell and Lucille M. Trussell as
lessees of the land describ	bed in Subdivision (d) of Paragraph X of the
Complaint as belonging to H	Plaintiff May Rhodes Trussell:
(a) For t	the year 1954:
	For increased power and labor costs \$20.00 Decreased crop production
	or a total of
(b) For	the year 1955:
	For increased power and labor costs \$ 30.00 Decreased crop production 87.50

(c) For	the year 1956:
	For increased power and labor costs \$ 52.50 Decreased crop production 131.25
	or a total of
3. By Plain	tiffs Stanley Trussell and Lucille M. Trussell
as lessees of the land des	cribed in Subdivision (j) of Paragraph X of the
Complaint as belonging to	Plaintiffs Erwin C. Georgeson and Lydia A.
Georgeson, being 10 acres	in Section 35, Township 12 S., Range 1 West,
S. B. B. & M.	
(a) For	the year 1954:
	For increased power and labor costs \$ 40.00 Decreased crop production 87.50
	or a total of \$127.50
(b) For	the year 1955:
	For increased power and labor costs \$ 60.00 Decreased crop production 175.00
	or a total of \$235.00
(c) For	the year 1956:
	For increased power and labor costs \$105.00 Decreased crop production
	or a total of
4. By Plain	tiffs Stanley Trussell and Lucille M. Trussell, as
lessees of the land descri	bed in Subdivision (h) of Paragraph X of the Com-
plaint as belonging to Reb	ecca P. Judson Dyer, Fred A. Dyer and Bernice J.
Judson Morrisey of which t	he Trussells had ten (10) acres under lease
during the years 1954 and	1955, and the entire seventeen (17) acres during
the year 1956:	
(a) For	the year 1954:
	For increased power and labor costs \$ 40.00 Decreased crop production 87.50

or a total of \$127.50

(b) For	the year 1955:
	For increased power and labor costs \$ 60.00 Decreased crop production 175.00
	or a total of
(c) For	the year 1956:
	For increased power and labor costs \$178.50 Decreased crop production
	or a total of
B. Damages suf	fered by Plaintiffs Franklin Trussell and Jane
L. Trussell:	
1. By Fran	aklin Trussell and Jane L. Trussell, as owners of
the land described in Sub	odivision (b) of Paragraph X of the Complaint:
(a) For	the year 1954;
	For increased power and labor costs \$ 40.00 Decreased crop production 87.50
	or a total of \$ 127.50
(b) For	the year 1955:
	For increased power and labor costs \$ 60.00 Decreased crop production 175.00
	or a total of \$235.00
(c) For	the year 1956:
	For increased power and labor costs \$ 105.00 Decreased crop production 262.50 For additional water facilities
	or a total of
C. Damages su	ffered by Plaintiff May Rhodes Trussell:
1 This D	laintiff suffered no demages personally she having

1. This Plaintiff suffered no damages, personally, she having been paid the land rentals due her by Plaintiffs Stanley Trussell and Lucille M. Trussell who suffered the damages heretofore specified and set forth under their names.

D. Damages suffered by Plaintiffs Frank E. Judson and Velda C.
Judson:
1. By Plaintiffs Frank E. Judson and Velda C. Judson, as
owners of land described in Subdivision (e) on Paragraph X of Complaint:
(a) For the year 1954:
For increased power and labor costs \$ 32.00 Decreased crop production
or a total of \$102.00
(b) For the year 1955:
For increased power and labor costs \$ 48.00 Decreased crop production
or a total of
(c) For the year 1956:
For increased power and labor costs \$ 84.00 Decreased crop production 210.00 For additional water facilities 2,686.60
or a total of
2. By Plaintiffs Frank E. Judson and Velda C. Judson, as
lessees of the lands described in Subdivision (f) of Paragraph X as belonging
to Plaintiff Alice N. Judson Suhrie:
(a) For the year 1954:
For increased power and labor costs \$220.00 Decreased crop production
or a total of
(b) For the year 1955:
For increased power and labor costs \$ 330.00 Decreased crop production 962.50 For additional water facilities 846.00
or a total of
(c) For the year 1956:
/ "

For	incre	ased	power	and	lab	or	CO	st	5	0	0	0	0	\$ 577.5	0
Dec	reased	crop	prod	actic	on o	0	o	0	0	٥	0	o	0	1,443.7	5
	C.200 (2)	+ -+ -1	of											\$2 027 2	<u>ح</u>

- E. Damages suffered by Plaintiff Alice N. Judson Suhrie:
- This Plaintiff suffered no damages personally, she having been paid the land rentals due her by Plaintiffs Frank E. Judson and Velda
 Judson who suffered the damages heretofore specified and set forth under their names.
 - F. Damages suffered by Charles A. Judson and Rebecca T. Judson:
- l. By Plaintiffs Charles A. Judson and Rebecca T. Judson, as owners of the land described in Subdivision (g) of Paragraph X of the Complaint:
 - (a) For the year 1954:

															\$208.00
Decrea	ased	crop	prod	uctio	on .	0	0	0	o	0	0	0	o	0	455.00
~T	Ф E3	tota7	of												\$663.00

(b) For the year 1955:

For increased power and labor costs . . . \$ 312.00 Decreased crop production 910.00 For additional water facilities 2,925.00

or a total of \$4,147.00

(c) For the year 1956:

- G. Damages suffered by Plaintiffs Rebecca Judson Dyer, Bernice J. Judson Morrisey and Fred A. Dyer.
- l. These Plaintiffs as the owners of the land described in Subdivision (h) of Paragraph X of the Complaint were actually occupying

and farming, and suffered damages on only seven (7) acres having leased ten (10) acres to Plaintiffs Stanley Trussell and Lucille M. Trussell.

(a) For the year 1954:

																			\$28.00
De	creas	sec	d crop	pro	odu	ıct	io	n	0	۰	0	0	0	0	0	0	0	0	61.25
	or	а	total	of	0	0	0	0	0	0	0	0	0	0	0	0	0	0	\$89.25

(b) For the year 1955:

For incre																
Decreased	d crop	pro	duc	cti	on	0	0	0	0	0	0	•	0	0	0	122.50
or a	total	of	0 (0	0	0	0	0	0	0	0	0	٥	0	\$164.50

(c) For the year 1956:

These Plaintiffs suffered no damages since the entire 17 acres was under lease to Plaintiffs Stanley Trussell and Lucille M. Trussell for the year 1956, who suffered the damages heretofore specified and set out under their names.

- H. Damages suffered by Plaintiffs Erwin C. Georgeson and Lydia A. Georgeson.
- l. These Plaintiffs as the owners of the land described in Subdivision (j) of Paragraph X of the Complaint suffered damages thereon and thereto by way of expenditures made by them for additional water facilities. No damages were suffered by these Plaintiffs personally, and none are allowed, for increased power and labor costs, or for decreased crop production since Plaintiffs had their irrigated lands leased out to tenants (except the home site, consisting of about one acre) which tenants paid Plaintiffs the land rent due them.
 - (a) For the year 1954:

For additional water facilities \$ 822.00

(b) For the year 1955:

For additional water facilities \$1,850.00

- (c) For the year 1956: no damages.
- I. Damages suffered by Plaintiffs Harold W. Pfeiffer and Helen L. Pfeiffer:
- l. By Plaintiffs Harold W. Pfeiffer and Helen L. Pfeiffer as the owners of the land described in Subdivision (k) of Paragraph X of the Complaint:
 - (a) For the year 1954:

For increas	sed power	and lab	or	cost	s .	o	0	0		\$131.00
Decreased	crop produ	action .	•	• •	0 0	0	•	0	•	253.75

or a total of \$384.75

(b) For the year 1955:

or a total of \$681.50

(c) For the year 1956:

These Plaintiffs conveyed their title to the property in question by a deed dated June 21, 1956, which deed contained the following reservation:

"Grantors reserve any and all causes of action which they now have, or which have arisen prior to delivery of this deed, against the City of San Diego for damages to the above-described property resulting, or which will result from the construction, operation, and maintenance of Sutherland Dam."

However, no claim was filed with the City for damages for the year 1956, and no allegation therefor was included in Plaintiffs' Supplemental Complaint, and no damages are allowed for 1956.

- J. Damages suffered by the Plaintiffs Ralph Cook and Jeanne V. Cook:
- l. These Plaintiffs acquired title to the land described in Subdivision (m) of Paragraph X of the Complaint, in May 1955, and suffered no damages for the year 1954.

(a) For the year 1955:	
For increased power and labor costs \$ 117.00 Decreased crop production	
or a total of	
(b) For the year 1956:	
For increased power and labor costs \$204.75 Decreased crop production	
or a total of	
K. Damages suffered by Plaintiff Southeastern California Association	
of Seventh-Day Adventists, a corporation:	
1. This Plaintiff as the owner of the lands described in	
Subdivision (1) of Paragraph X of the Complaint:	
(a) For the year 1954:	
For increased power and labor costs \$ 400.00 Decreased crop production 875.00	
or a total of	
(b) For the year 1955:	
For increased power and labor costs \$ 600.00 Decreased crop production 1,750.00 For additional water facilities 2,384.00	
or a total of	
(c) For the year 1956:	
For increased power and labor costs \$1,050.00 Decreased crop production 2,625.00 For additional water facilities	
or a total of	
XI.	

XI.

The Court finds that it is true that Plaintiffs, at the time they filed their claim against The City of San Diego, and at the time they filed their Complaint herein, had no actual notice or knowledge of the City's plans

and intentions or what its policy would be with reference to limiting its storage of Santa Ysabel Creek water back of Sutherland Dam, solely to the excess and surplus over and above the Plaintiffs' reasonable requirements, and for that reason they filed a second cause of action to their Complaint alleging permanent damages. However, Defendant City in its Answer denied that it had appropriated to its own use, profit and enjoyment all the waters of Santa Ysabel Creek originating above said Dam and denied any permanent injury or damage to Plaintiffs or their respective lands. There was no evidence introduced by either party on the subject of permanent damages but the case was tried on the theory that permanent damages were not an issue before the court. Accordingly, no finding is necessary on the Second Cause of Action set out in Plaintiffs' Complaint, and none will be made.

XII.

The Court finds that the Defendant, The City of San Diego, will, unless restrained, continue in the future its current policy and practice of withholding behind Sutherland Dam to the extent of its capacity, all the water of the Santa Ysabel Creek originating above the dam for distribution and sale of that water for municipal purposes, to the continuing injury and damage of the Plaintiffs and each of them and their respective lands.

XIII.

The Defendant, The City of San Diego, stipulated with the Plaintiffs that the rights of the Parties herein should be and remain as they were on January 30, 1954. There was no diversion from the Sutherland Reservoir out of the watershed and into the City's distribution system until about March 26, 1954, when water from Sutherland Dam was, for the first time, diverted through a tunnel into the San Vicente Reservoir of The City of San

Diego in order to test the newly constructed Sutherland tunnel and diversion works. This test continued into April 1954, and constituted the major part of the total 4,322.6 acre-feet withdrawn from that reservoir. Thereafter there were no other diversions from Sutherland Dam that year. The next diversions occurred one each in the years 1955 and 1956 and were of relatively small amounts of water.

From the foregoing facts, the Court concludes:

CONCLUSIONS OF LAW

I.

That Plaintiffs, as the owners of lands described and set out in the Complaint, were and each of them now are, except Plaintiffs Harold W. Pfeiffer and Helen L. Pfeiffer, the owners of rights in and to the waters of the Santa Ysabel Creek prior and paramount to the appropriative rights of the Defendant, The City of San Diego.

II.

That the Plaintiffs were, and each of them now are, except Plaintiffs. Harold W. Pfeiffer and Helen L. Pfeiffer, as the owner of said prior and paramount rights, entitled to have sufficient amounts of the flow of the Santa Ysabel Creek, surface and subsurface, come down to them to meet their reasonable requirements for beneficial use on their said respective lands, without interference or interruption by the Defendant. However, none of said Plaintiffs are entitled to transport or to use any of the waters of said creek outside its watershed.

III.

That the Plaintiffs in order to meet their reasonable requirements

were not and are not obliged to change their long established methods of diversion and use of the waters of the Santa Ysabel Creek, which this Court has found were reasonable, and are entitled to have the normal static water table or water level under their respective lands, on which they are dependent for their well water, be and remain as it would have been if Sutherland Dam had not been built by the Defendant. The Plaintiffs are entitled to have such normal static water level under their said lands and in their said wells, range between 12 feet and 20 feet below the ground surface. Defendant is not entitled to withhold or store any of the natural flow of Santa Ysabel Creek upstream from Plaintiffs' said lands when the average static water level under Plaintiffs' said lands and in their wells falls 20 feet below the surrounding ground surface, and Defendant is enjoined and restrained from so doing.

TV.

That the normal static water level under Plaintiffs' lands could and would be determined and established by the average of the static water levels in Plaintiffs' several wells, but the parties to this action may agree to designate certain wells as representative of the general area involved for that purpose. The static water level in the wells should be measured and recorded monthly and a copy of the report of the static water levels should be filed with the Court in this case and topies delivered to each of the parties to this action or to their designated representatives. If the parties are unable to agree upon the wells which are to be measured and read for determining the static water level and the procedure to be followed in connection therewith, an application may be made to this Court by any party to the action for a hearing to determine and designate the number and the location of the test wells and the procedure to be followed for measuring and determining the static

water level, and after notice and hearing, the Court shall so decide and determine.

V.

That the Plaintiffs are, respectively, entitled to receive from and be paid by Defendant The City of San Diego, damages in the amounts specified and set forth in Finding No. X, which are here summarized and totaled as follows:

- A. To Plaintiffs STANLEY TRUSSELL and LUCILLE M. TRUSSELL damages in the sum of SEVEN THOUSAND NINE HUNDRED SEVENTY-EIGHT AND 95/100 (\$7.978.95) DOLLARS.
- B. To Plaintiffs FRANKLIN TRUSSELL and JANE L. TRUSSELL damages in the sum of ONE THOUSAND NINE HUNDRED SEVENTY-TWO AND 99/100 (\$1,972.99) DOLLARS.
 - C. To Plaintiff MAY RHODES TRUSSELL, No Damages.
- D. To Plaintiffs FRANK E. JUDSON and VELDA C. JUDSON damages in the sum of EIGHT THOUSAND ONE HUNDRED THIRTY-ONE AND 60/100 (\$8,131.60)
 - E. To Plaintiff ALICE N. JUDSON SUHRIE, No Damages.
- F. To Plaintiffs CHARLES A. JUDSON and REBECCA T. JUDSON damages in the sum of EIGHT THOUSAND FIVE HUNDRED NINETY-FIVE AND 98/100 (\$8,595.98)

 DOLLARS.
- G. To Plaintiffs REBECCA JUDSON DYER, BERNICE J. JUDSON MORRISEY and FRED A. DYER, damages in the sum of TWO HUNDRED FIFTY-THREE AND 75/100 (\$253.75) DOLLARS.
- H. To Plaintiffs ERWIN C. GEORGESON and LYDIA A. GEORGESON damages in the sum of TWO THOUSAND SIX HUNDRED SEVENTY-TWO AND NO/100 (\$2,672.00)

 DOLLARS.

- I. To Plaintiffs HAROLD W. PFEIFFER and HELEN L. PFEIFFER damages in the sum of ONE THOUSAND SIXTY-SIX AND 25/100 (\$1,066.25) DOLLARS.
- J. To Plaintiffs RALPH COOK and JEANNE V. COOK, damages in the sum of ONE THOUSAND EIGHT HUNDRED SEVEN AND 12/100 (\$1,807.12) DOLLARS.
- K. To Plaintiffs SOUTHEASTERN CALIFORNIA ASSOCIATION OF SEVENTH-DAY ADVENTISTS, a corporation, damages in the sum of FOURTEEN THOUSAND THREE HUNDRED FORTY-FIVE AND 29/100 (\$14,345.29) DOLLARS.

VI.

That the Plaintiffs are entitled to have this Court exercise its equitable powers to protect their rights against the threatened continuing invasion thereof by Defendant, since there has been no such public use made of any of the waters stored in or diverted out of Sutherland Reservoir to an extent sufficient to deter this Court from granting appropriate injunctive relief; furthermore, even if some public use had been made of some of the said waters, Defendant would not be and is not entitled to assert a claim of public use because of the stipulation found in Finding No. XIII to have been made by it with the Plaintiffs, wherein the rights of these parties were fixed as of January 30, 1954.

VII.

The Court should and does hereby reserve jurisdiction in this action to grant appropriate relief to any party thereto or to their successors in interest upon application duly made therefor, notice thereof and upon a proper evidentiary showing of merit.

VIII.

That the Plaintiffs are entitled to recover their costs incurred herein.

LET JUDGMENT BE ENTERED ACCORDINGLY.

Dated this 17 day of December, 1957.

/s/ Arthur L. Mundo
JUDGE OF THE SUPERIOR COURT

JUDGMENT

IN THE SUPERIOR COURT OF THE STATE OF CALIFORNIA IN AND FOR THE COUNTY OF SAN DIEGO

STANLEY TRUSSELL, et al.,

Plaintiffs,

VS.

THE CITY OF SAN DIEGO, a Municipal Corporation,

Defendant.

NO. 205,488

JUDGMENT

The above entitled action coming on regularly for hearing the 20th day of August, 1957, before the Honorable Arthur L. Mundo presiding, and SWING, SCHARNIKOW & STANIFORTH by Phil D. Swing and C. H. Scharnikow appearing for Plaintiffs, and AARON W. REESE and ALAN M. FIRESTONE, Deputy City Attorneys appearing for the Defendant, and oral testimony and documentary evidence having been introduced on that day and on succeeding days to which said case was regularly continued and the taking of evidence having finally been completed on the 14th day of October, 1957, and said cause having been orally argued by respective counsel on the 17th, 18th, and 21st of October, 1957, and written briefs filed, the case was submitted and the court being fully informed and advised in the premises, and after due deliberation thereon, having filed its Findings of Fact and Conclusions of Law, and having directed that judgment be entered in accordance therewith; now therefore by reason of the law and the findings aforesaid:

- IT IS HEREBY ORDERED, ADJUDGED AND DECREED:
- 1. That Plaintiffs, as the owners of lands described and set out

in the First Cause of Action of the Complaint, were and each of them now are, except Plaintiffs Harold W. Pfeiffer and Helen L. Pfeiffer, the owners of rights in and to the waters of the Santa Ysabel Creek prior and paramount to the appropriative rights of the Defendant, The City of San Diego.

- 2. That the Plaintiffs were, and each of them now are, except Plaintiffs Harold W. Pfeiffer and Helen L. Pfeiffer, as the owner of said prior and paramount rights, entitled to have sufficient amounts of the flow of the Santa Ysabel Creek, surface and subsurface, come down to them to meet their reasonable requirements for beneficial use on their said respective lands, without interference or interruption by the Defendant. However, none of said Plaintiffs are entitled to transport or to use any of the waters of said Creek outside its watershed.
- 3. That the Plaintiffs, in order to meet their reasonable requirements were not and are not obliged to change their long established methods of diversion and use of the waters of the Santa Ysabel Creek, which this Court has found were reasonable, and are entitled to have the normal static water table or water level under their respective lands, on which they are dependent for their well water, be and remain as it would have been if Sutherland Dam had not been built by the Defendant. The Plaintiffs are entitled to have such normal static water level under their said lands and in their said wells, range between 12 feet and 20 feet below the ground surface. Defendant is not entitled to withhold or store any of the natural flow of Santa Ysabel Creek upstream from Plaintiffs' said lands when the average static water level under Plaintiffs' said lands and in their wells falls 20 feet below the surrounding ground surface, and Defendant by its operation of Sutherland Dam has violated and invaded the rights of Plaintiffs to their damage by withholding all of the waters of said Creek originating above said Dam in the amount hereinafter set forth.

- 4. That the damages caused the several Plaintiffs by Defendant The City of San Diego invading their rights by its operation of Sutherland Dam, and the withholding of all water originating above said Dam, are the amounts specified and set out below opposite the names of the respective Plaintiffs which Defendant is ordered to pay:
 - A. To Plaintiffs STANLEY TRUSSELL and LUCILLE M. TRUSSELL damages in the sum of SEVEN THOUSAND NINE HUNDRED SEVENTY— EIGHT AND 95/100 (\$7,978.95) DOLLARS.
 - B. To Plaintiffs FRANKLIN TRUSSELL and JANE L. TRUSSELL damages in the sum of ONE THOUSAND NINE HUNDRED SEVENTY-TWO AND 99/100 (\$1.972.93) DOLLARS.
 - C. To Plaintiff MAY RHODES TRUSSELL, No Damages.
 - D. To Plaintiffs FRANK E. JUDSON and VELDA C. JUDSON damages in the sum of EIGHT THOUSAND ONE HUNDRED THIRTY-ONE AND 60/100 (\$8,131.60) DOLLARS.
 - E. To Plaintiff ALICE N. JUDSON SUHRIE, No Damages.
 - F. To Plaintiffs CHARLES A. JUDSON and REBECCA T. JUDSON damages in the sum of EIGHT THOUSAND FIVE HUNDRED NINETY-FIVE AND 98/100 (\$8,595.98) DOLLARS.
 - G. To Plaintiffs REBECCA JUDSON DYER, BERNICE J. JUDSON

 MORRISEY, and FRED A. DYER damages in the sum of TWO HUNDRED

 FIFTY-THREE AND 75/100 (\$253.75) DOLLARS.
 - H. To Plaintiffs ERWIN C. GEORGESON and LYDIA A. GEORGESON damages in the sum of TWO THOUSAND SIX HUNDRED SEVENTY-TWO AND NO/100 (\$2,672.00) DOLLARS.
 - I. To Plaintiffs HAROLD W. PFEIFFER and HELEN L. PFEIFFER damages in the sum of ONE THOUSAND SIXTY-SIX AND 25/100 (\$1,066.25) DOLLARS.

- J. To Plaintiffs RALPH COOK and JEANNE V. COOK, damages in the sum of ONE THOUSAND EIGHT HUNDRED SEVEN AND 12/100 (\$1,807.12) DOLLARS.
- K. To Plaintiffs SOUTHEASTERN CALIFORNIA ASSOCIATION OF SEVENTH-DAY ADVENTISTS, a corporation, damages in the sum of FOURTEEN THOUSAND THREE HUNDRED FORTY-FIVE AND 29/100 (\$14,345.29) DOLLARS.
- 5. That the normal static water level under Plaintiffs' lands is to be determined and established by the average of the static water levels in Plaintiffs' several wells, but the parties to this action may agree to designate certain wells as representative of the general area involved for that purpose. The static water level in the wells should be measured and recorded monthly by the Plaintiffs and a copy of the report of the static water levels should be filed with the Court in this case and copies delivered to each of the parties to this action or to their designated representatives. If the parties are unable to agree upon the wells which are to be measured and read for determining the static water level and the procedure to be followed in connection therewith, an application may be made to this Court by any party to the action for a hearing to determine and designate the number and the location if the test wells and the procedure to be followed for measuring and determining the static water level, and after due notice and hearing, the Court shall so decide and determine.
- 6. The Plaintiffs are entitled to have this Court exercise its equitable powers to protect their rights against the threatened continuing invasion thereof by Defendant, since there has been no such public use made of any of the waters stored in or diverted out of Sutherland Reservoir to an

extent sufficient to deter this Court from granting appropriative injunctive

relief; furthermore, Defendant is not entitled to assert a claim of public

use because of the stipulation found in Finding No. XIII to have been made

by it with the Plaintiffs, wherein the rights of these parties were fixed as

of January 30, 1954. Accordingly, it is ordered, adjudged and decreed that

the Defendant, The City of San Diego, their agents, servants and employees,

and all persons acting by, through or under them, be and they are hereby

enjoined and restrained from storing or withholding any of the natural flow

of Santa Ysabel Creek upstream from Plaintiffs' said lands whenever the

static water level under Plaintiffs' said lands and in their said wells

falls, and is 20 feet or more below the surrounding ground surface.

7. The Court hereby reserves jurisdiction in this action to grant

appropriate relief to any party thereto or to their successors in interest

upon application duly made therefor, and after due notice thereof and upon a

proper evidentiary showing of merit.

8. Plaintiffs are entitled to recover their costs incurred

herein.

DATED: December 17, 1957.

/s/ Arthur L. Mundo

APPENDIX H

LAND USE, LAND CLASSIFICATION, AND CONSUMPTIVE USE OF WATER IN SAN DIEGUITO RIVER WATERSHED

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LAND USE, LAND CLASSIFICATION, AND CONSUMPTIVE USE OF WATER IN SAN DIEGUITO RIVER WATERSHED

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LAND USE IN HYDROLOGIC UNITS AND SUBUNITS OF SAN DIEGUITO RIVER WATERSHED FOR 1956-57

In Acres

	Total		1,24 2,96 1,54 2,64	924 163	2,049	2,552	2,363 2,318 612 2,859 108 582 301 9,143 478 9,621
••	Coastal: Unit		162 214 72 0	121	619	834	516 133 612 814 13 237 130 2,455 129 2,584 3,418
it :	Subtotal		230 17 22 15	277	566	692	1,382 2,175 0,942 77 325 136 6,037 6,351
Central Un	Hodges: Sub-		226 10 22 22 13	168	444	554	1,262 0 1,791 63 84 80 3,724 3,916 4,470
Ce	San Pasqual: Sub-		このとれ	109	122	138	938 913 0 151 14 241 56 2,313 122 2,435 2,435
••	Subtotal		1.86%	526 108	864 162	1,026	465 10 103 18 20 35 651 651 1,712
	Guejito: Sub- :E		0000	40	10	Т	0000000
d Unit	Roden :(Sub-		0000	000	9 0	10	13 19 19 29
Inland	Pamo : Sub- :		0 0 0 0 0	32	101	61	76 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
	:Ramona : Sub- :		45448 84448	108	768	908	376 10 0 100 15 18 35 29 29 583
	Suther-: land :F Sub- :		08000	13	34	94	0000000000
	Class and type of land use	URBAN AND SUBURBAN LANDS	Residential Commercial Industrial Parks and cemeteries	Miscellaneous urban and suburban Vacant	Net urban and sub- urban area Streets and roads	Gross urban and suburban area	Alfalfa and pasture Avocados Beans Citrus Deciduous and vineyard Hay and grain Truck crops Net irrigated area Streets and roads Gross irrigated area GROSS WATER SERVICE AREAS

LAND USE IN HYDROLOGIC UNITS AND SUBUNITS OF SAN DIEGUITO RIVER WATERSHED FOR 1956-57 (continued)

In Acres

	Motal		255 51,153 1,314 13,234 613	66, 569	70,065		66,948 29,300 34,302	2,383	135,780	138,519	208,584	220,757
0.0	Coastal: Unit		6,219 6,219 14,299 64	10,869	11,442		6,299 3,606 2,270	38	12,426	12,676	24,118	27,536
Unit	Subtotal		0 10,390 787 3,762 59	14,998	15,786		22, 917 6, 983 4, 595	327	36,898	37,639	53,425	60,468
Central Ur	1 0 1 4		6,762 661 2,993 42	10,458	11,007		9,660 3,621 3,183	325 873	18,238	18,601	29,608	34,078
Ü	San Pasqual Sub- unit		3,628 126 769 17	4,540	4,779		13,257 3,362 1,412	294	18,660	19,038	23,817	26,390
	Subtotal		34,544 495 5,173 6,173	40,702	42,837		37,732 18,71 27,437	602	86,456	88,204	131,041	132,753
	Guejito Sub- unit		5,452 0 149	5,609	5,903		5,870 589 1,786	0 m 0	8,248	8,416	14,319	14,320
nd Unit	I pag pal		0 1,438 23 416 29	1,906	2,004		3,566 4,335 329	110	8,423	8,592	10,596	10,625
Inland	Pamo Sub-		ο 5,149 52 111 0	5,312	5,591		13,124 6,981 9,628	187	30,442	31,065	36,656	36,801
	Ramona Sub- unit		0 11,869 372 4,450 445	17,136	18,035		9,197 3,864 3,128	327	16,604	16,940	34,975	36,466
••	Suther- land Sub- unit		0 10,636 48 47 47	10,739	11,304		5,975 2,942 12,566	594 653	22,739	23,191	34,495	34,541
	Class and type of land use	NONIRRIGATED AGRICULTURAL LANDS	Field crops Pasture and grain Orchard and vineyard Idle and fallow Miscellaneous	Net nonirrigated agricultural area Streets and roads	Gross nonirrigated agricultural area	NATIVE VEGETATION	Light brush and grass lands Medium brush Heavy brush and trees	Water surfaces Barren and waste	Net native vegetation Streets and roads	Gross native vegetation	GROSS NONWATTER SERVICE AREAS	GRAND TOTALS

TABLE H-2

STANDARDS FOR CLASSIFICATION OF LANDS FOR WATER SERVICE

Land:	
	Characteristics Characteristics
class:	

Irrigable Lands

- V Smooth lying valley lands with slopes up to six per cent in general gradient, in reasonably large-sized bodies sloping in the same plane, or slightly undulating lands which are less than four per cent in general gradient. The soils have medium to deep effective root zone, are permeable throughout, and free of salinity, alkalinity, rock or other conditions limiting crop adaptability of the land. These lands are suitable for all climatically adapted crops.
- VI Similar in all respects to Class V, except for having fairly coarse textures and low moisture-holding capacities, which in general make these lands unsuited for the production of shallow-rooted crops because of the frequency of irrigations required to supply the water needs of such crops.
- Vp Similar in all respects to Class V, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops, such as irrigated grain and pasture.
- Vr Similar in all respects to Class V, except for the presence of rock on the surface or within the plow zone in sufficient quantity to prevent use of the land for cultivated crops.
- Rolling and undulating lands with slopes up to a maximum of 20 per cent for rolling large-sized bodies sloping in the same plane, and grading down to a maximum slope of less than 12 per cent for undulating lands. The soils are permeable with medium to deep effective root zones, and are suitable for the production of all climatically adapted crops. The only limitation is that imposed by topographic conditions, which affect the ease of irrigation and the amount of these lands that may ultimately be developed for irrigation.
- Hl Similar in all respects to Class H, except for having fairly coarse textures and low moisture-holding capacities which in general makes these lands unsuited for the production of shallow-rooted crops because of the frequency of irrigations required to supply the water needs of such crops.
- Hp Similar in all respects to Class H, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops.

STANDARDS FOR CLASSIFICATION OF LANDS FOR WATER SERVICE (continued)

Land : class :	Characteristics
Hr	Similar in all respects to Class H, except for the presence of rock on the surface or within the plow zone in sufficient quantity to restrict use of the land to noncultivated crops.
Hpr	Similar in all respects to Class H, except for depth of the effective root zone and the presence of rock on the surface or within the root zone in sufficient quantity to restrict use of these lands to noncultivated crops.
Ht	Similar in all respects to Class H, except for topographic limitations. These lands have smooth slopes up to 30 per cent in general gradient for large-sized bodies sloping in the same plane, and slopes up to 20 per cent for rougher and more undulating topography. These lands will probably never become as highly developed as other "H" classes of land.
Htp	Similar in all respects to Class Ht, except for depth of the effective root zone, which limits use of these lands to shallow-rooted crops.
Htr	Similar in all respects to Class Ht, except for the presence of rock on the surface or within the plow zone in sufficient quantity to restrict use of these lands to noncultivated crops.
Htpr	Similar in all respects to Class Ht, except for depth of the effective root zone and the presence of rock on the surface or within the root zone, which limits use of these lands to noncultivated shallow-rooted crops.
	Urban and Recreational Lands
U	Urban areas which are devoted to intensive residential, commercial, recreational, and industrial development.
R	Areas presently used for residential purposes.
AR	Existing areas which have reached ultimate development of a combination of agricultural and residential class which includes small acreages of agriculture together with residences, and from which some agricultural income is derived. The average number of acres per residence is indicated by a number in the symbol.

STANDARDS FOR CLASSIFICATION OF LANDS FOR WATER SERVICE (continued)

Land class	Characteristics
P	Existing and potential county, state, and federal parks, race tracks, fair grounds, and other very low water using areas.
RV	Areas that are capable of full urban development, and in some instances, include acreages of present urban development.
N	Includes all land which fail to meet the requirements of the above classes.

8--E

AND SUBUNITS OF SAN DIEGUITO RIVER WATERSHED CLASSIFICATION OF LANDS IN HYDROLOGIC UNITS

In Acres

Inland Unit Pamo Roden Juejito Sub- Sub-
--

A CARL AND COMPANY AND A CARLON CARLON CONTRACTOR OF THE PROPERTY AND A STREET OF THE PROPERTY	And the second s	Average and the second land and the second lands	Inland	Unit	And the second control of the second control		Ce	Central Unit	T. C.		A STATE OF THE STA
Land class	Suther :	Ramona	Pamo	Roden Sub-	Juejíto Sub-	Subtotal	Sen Pasqual Sub-	Hodges:	Subtotal	Coastal: Unit	Total
APPENDENT AND THE PARTIES THE THE THE THE TAIL ALLERS AND APPENDENT RECEIVED AND RECEIVED AND THE	unit	unit :		unit			unit		CO C		
POTENTIAL URBAN AND SUBURBAN LANDS											
r R	00	339	25	00	00	364	15	117	132	34	2000 4000 4000 4000 4000 4000 4000 4000
AR-1 AR-2 P	000	000	000	000	000	000	000	805	805 0 24	3 44 163	808 44 187
RV*	0	245	0	0	0	245	0	1,831	1,831	3,231	5,307
RV* Ht	0	0	0	0	0	0	0	927	726	1,607	2,534
RV*	0	0	0	0	0	0	0	477	†177	1,079	1,853
$\frac{RV*}{V}$	0	0	0	0	0	0	0	0	0	101	101
Gross potential urban and suburban lands	0	584	25	0	0	609	15	1,630	4,645	6,361	11,618
IRRIGABLE LANDS											
V V1 Vp Vr	271 0 0 24	2,920 0 247	105	0000	405 0 0	3,701 56 360 24	1,673	625 292 0	2,298	1,760	7,759 2,515 360 24

18,778 13,247

1,086

6,028 1,678

4,699 199

1,329 1,017

11,664

3,924 46

713 966

1,458

3,093

2,476

H H H

8,303

200

10,009

1,560

CLASSIFICATION OF LANDS IN HYDROLOGIC UNITS AND SUBUNITS OF SAN DIEGUITO RIVER WATERSHED (continued)

In Acres

	00 0	: Coastal: Total	00		503 68 1,713	196 876 5,817 6,131 896 13,141 2,598 3,410 9,855 1,552 1,240 7,981	3,366 1,267 10,162	25,997 13,043 91,601	30,642 19,407 103,219	29,826 8,129 117,538	
Tutter IIntt	central unit	Pasqual: Hodges: Sub- : Sub- :Subtotal:	: unit :		1 459	73 5,255 1,061 1,552	361	15,038	19,668	14,410	
	San	** 40	: unit		71	123 876 1,537 0	3,005	10,959	10,974	15,416	,
	••	so: :Subtotal	••		1,142	4,745 6,114 3,847 5,189	5,529	52,561	53,170	79,583	
	••	•••	: unit		0	2,626	656	7,931	7.931	6,389	
Inland Unit		60 00	: unit		0	218 213 650 18	26	2,836	2,836	7,789	1
Tnl		Pamo	: unit		218	494 830 2,212 1,528	845	8,454 2,836	8,479	12,392 28,322 7,789	101
	l;	: Sub-	unit		164	3,098 483 377 1,873	2,332	23,490	24,074	12,392	101 /0 // /0
	Suther-	: land : Sub-	: unit		160	816 1,962 575 1,696	1,670	9,850	9,850	24,691	- 0
		Land class		IRRIGABLE LANDS (continued)	$_{ m Hr}$	Hpr Ht Htp Htr	Htpr	Gross irrigable lands	GROSS WATER SERVICE AREAS	LANDS NOT SUSCEPTIBLE OF URBAN OR IRRIGATION DEVELOPMENT	

* The numerator of the land classification fraction represents the ultimate projected development, while the denominator represents the present land classification.

TABLE H-4

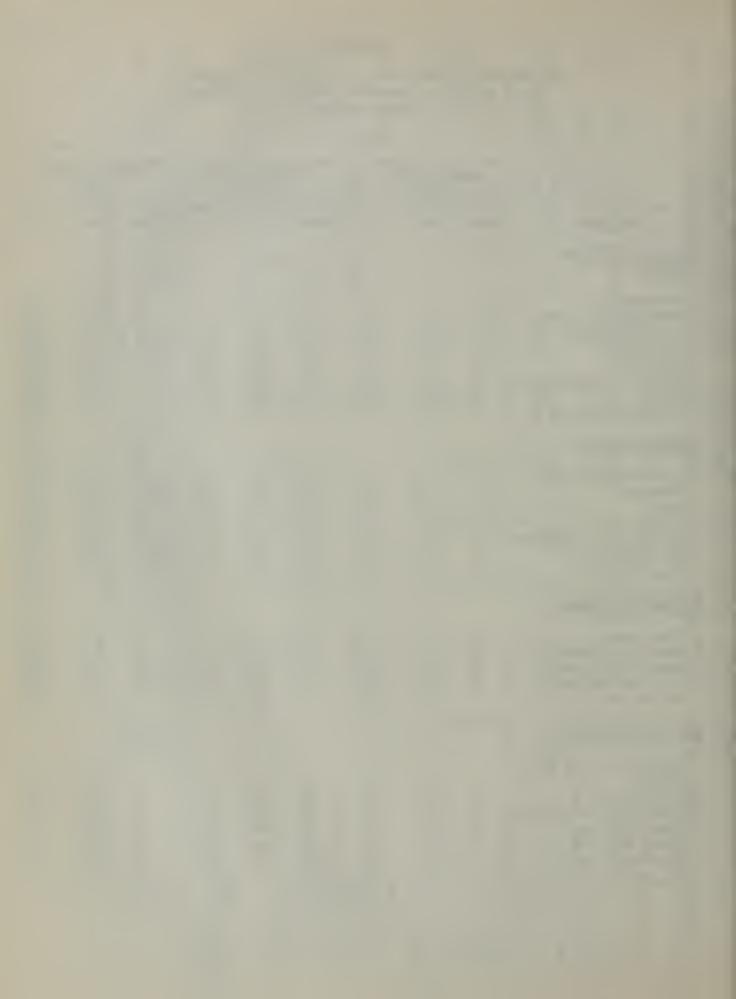
PROBABIE ULTIMATE PATTERN OF LAND USE IN HYDROLOGIC UNITS AND SUBUNITS OF SAN DIEGUITO RIVER WATERSHED

				ឝ	In Acres						
	00		Inland	d Unit		**	Ce	Central Unit	it	00	
Land class	Suther-: land: Sub-: unit:	Ramona : Sub-	Pamo : Sub- : unit :	Roden Sub- unit	Guejito Sub- unit	: :Subtotal:	San Pasqual Sub-	Hodges: Sub-	: :Subtotal:	Coastal: Unit	Total
POTENTIAL URBAN AND SUBURBAN LANDS											
Residential Commercial Industrial	000	269	00	000	000	269	460	1,899	1,903	2,558	4,730 1,472 1,517
suburban area	0	438	19	0	0	457	Ħ	3,092	3,103	4,159	7,719
exclusions	0	146	9	0	0	152	7	1,538	1,542	2,205	3,899
Gross urban and suburban area	0	584	25	0	0	609	15	4,630	4,645	6,364	11,618
IRRIGABLE LANDS											
Alfalfa and pasture Avocados	4,678	7,353	1,628	476 836	752 23,284	14,887	2,516	400 10,618	2,916	7,304	18,003 24,609
Citrus	00	73,505	0	0	0	0,000	0	00	0	00	43064
Deciduous and vineyard	2,825	4,611	4,728	900	1,500	491°71 0	100	000	200	100	14,464
Truck crops	0	3,400	189	300	1,791	5,680	1,957	1,054	3,011	2,606	11,297
Net irrigable area Streets, roads, and other	7,503	18,626	6,545	2,262	6,527	41,463	8,552	12,172	20,724	10,210	72,397
exclusions	2,347	4,864	1,909	574	1,404	11,098	2,407	2,866	5,273	2,833	19,204
Gross irrigable area	9,850	23,490	8,454	2,836	7,931	52,561	10,959	15,038	25,997	13,043	91,601
Gross water service areas 9,850	s 9,850	24,074	8,479	2,836	7,931	53,170	10,974	19,668	30,642	19,401	103,219
LANDS NOT SUSCEPTIBLE OF URBANOR IRRIGATION DEVELOPMENT 2	AN 24,691	12,392	28,322	7,789	6,389	79.583	15,416	14,410	29,826	8,129	117,538
GRAND TOTALS	34,541	36,466	36,801	10,625	14,320	132,753	26,390	34,078	897,09	27,536	220,757

ESTIMATED MEAN SEASONAL UNIT VALUES OF CONSUMPTIVE USE OF WATER IN HYDROLOGIC UNITS OF SAN DIEGUITO RIVER WATERSHED

In Feet

	: In	land Un	it	: Cer	ntral U	nit :	Coa	astal Un	nit
	:	:Preci-		:	:Preci		3	:Preci	
Class and type of				:Applie					:Total
land use	: water	:tion	:	: water	:tion	:	water	:tion	:
IDDAN AND CUDUDDAN									
URBAN AND SUBURBAN LANDS									
LANDS									
Residential	1.2	1.0	2.2	1.3	0.9	2.2	1.3	0.9	2.2
Miscellaneous urban	~	2.0	~ . ~		007	~ • •	100	0.,	~ ~ ~
and suburban	1.2	1.0	2.2	1.3	0.9	2.2	1.3	0.9	2.2
Commercial	0.5	0.5	1.0	0.5	0.5	1.0	0.5	0.5	1.0
Industrial	1.5	0.6	2.1	1.5	0.6	2.1	1.5	0.6	2.1
Parks and cemeteries	0.5	0.6	1.1	0.5	0.6	1.1	0.5	0.6	1.1
Vacant	0	0.6	0.6	0	0.6	0.6	0	0.5	0.5
Streets and roads	0	0.5	0.5	0	0.5	0.5	0	0.5	0.5
TRATELEMENT TANKS									
IRRIGATED LANDS									
Alfalfa and pasture	2.3	1.2	3.5	2.5	1.1	3.6	2.3	1.0	3.3
Avocados	1.5	1.0	2.5	1.6	0.9	2.5	1.5	0.9	2.4
Beans	0.8	0.8	1.6	1.2	0.9	3.0	0.8	0.8	1.6
Citrus	1.3	1.0	2.3	1.4	0.9	2.3	1.3	0.9	2.2
Deciduous and vineyar	_	1.2	2.6	1.6	1.2	2.8	1.6	1.0	2.6
Hay and grain	0.5	1.0	1.5	0.6	0.9	1.5	0.6	0.8	1.4
Truck crops	1.1	0.9	2.0	1.3	0.8	2.1	1.2	0.8	2.0
·									
NONIRRIGATED LANDS									
B. 1.			•						
Field crops	0	0	0	0	0	0	0	1.0	1.0
Pasture and grain	0	1.6	1.6	0	1.2	1.2	0	1.0	1.0
Orchard and vineyard Idle and fallow	0	0.8	0.8	0	1.3	1.3	0	1.0	1.0
Miscellaneous	ő	1.6	1.6	Ö	1.2	1.2	Ö	1.0	1.0
	·	1.0	1.0	Ŭ	T&	10 K		1.0	1.0
NATIVE VEGETATION									
Light brush and grass									
lands	0	1.6	1.6	0	1.2	1.2	0	1.0	1.0
Medium brush	0	1.8	1.8	0	1.3	1.3	0	1.1	1.1
Heavy brush and trees		2.0	2.0	0	1.4	1.4	0	1.1	1.1
Phreatophytes	0	4.7	4.7	0	4.7	4.7	0	4.5	4.5
Water surfaces	0	4.3	4.3	0	4.2	4.2	0	4.1	4.1
Barren and waste	0	0.8	0.8	0	0.6	0.6	0	0.6	0.6



APPENDIX I

ESTIMATES OF MONTHLY EVAPORATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57



APPENDIX I

ESTIMATES OF MONTHLY EVAPORATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57^a

In Inches

	0	0	Pamo	0	San Pasqual	0
Season	: Sutherland	0	Reservoir	0	Reservoir	: Hodges
and month	: Reservoir	•	site ^b	٥	site	: Reservoir
1936~37						
October	2.07		2 (2			
November	3.27		3.60		1.69	1.59
December	3.66		4.07		3.68	3.47
January	3.29		3.63		2.34	2.21
February	1.91		1.84		1.94	1.83
March	3.06		3.33		3.99	3.76
April	2.84		3.04		2.89	2.73
May	4.26		4.89		4.12	3.89
June	4.37		5.03		6.33	5.97
July	5.59		6.61		7.10	6.70
August	6.19 5.81		7.38		7.31	6.90
September	5.84		6.89		7.60	7.17
pebremper	7.04		6.93		6.32	<u>5.96</u>
TOTALS	50.09 ^c		57.24		55.31d	52.18
1937-38						
October	4.75		5.51		4.66	4.40
November	3.27		3.60		2.49	
December	2.96		3.20		2.26	2.35 2.13
January	3.05		3.31		2.00	1.89
February	2.19		2.21		1.44	1.36
March	2.56		2.68		3.43	3.24
April	3.91		4.43		4.80	4.53
May	4.45		5.14		5.57	5.25
June	5.68		6.72		6.47	6.10
July	6.35		7.59		7.70	7.26
August	5.87		6.96		7.31	6.90
September	6.16		7.34		6.87	6.43
MOMAS =	On Charles and Administration of the Control of the		OF THE REAL PROPERTY.		Office and the second	
TOTALS	51.20 ^c		58.69		55.00 ^d	51.89

ESTIMATES OF MONTHLY EVAPORATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57^a (continued)

In Inches

п				
_		Pamo	: San Pasqual	•
Season	: Sutherland :	Reservoir Site ^b	: Reservoir : site	: Hodges : Reservoir
and month	: Reservoir :	proe	: site	: Reservoir
1938-39				
October	4.55	5.26	4.24	4.00
November	4.24	4.85	3.92	3.70
December	2.69	2.84	2.16	2.04
January	2.51	2.23	1.69	1.59
February	2.41	2.50	2.34	2.21
March	2.61	2.75	2.09	1.97
April	3.93	4.47 6.29	3.22 6.07	3.04
May June	5.3 ⁴ 6.32	7.55	8.00	5•73 7•55
July	6.70	8.04	8.32	7.84
August	6.24	7.45	7.41	6.99
September	4.33	4.97	4.97	4.69
moma t a	51.57 ^c	59.20	54.43 ^d	E1 2E
TOTALS	ンエ・ント	79.20	24.43	51.35
1939-40				
October	4.57	5.28	4.61	4.35
November	3.23	3 • 55	2.74	2.59
December	2.88	3.10	2.07	1.95
January	2.02	1.98	1.53	1.44
February	2.13	2.13	2.23	2.10
March	3 • 55	3·97 4·22	3.16 4.25	2.98 4.01
April May	3•75 5•60	6.62	6.38	6.02
June	5. 7 3	6.79	6.82	6.43
July	7.27	8.78	8.61	8.12
August	6.16	7.34	8.02	7.58
September	5.13	6.01	5.12	4.83
TOTALS	52.02 ^c	59.78	55.54 ^d	52.40
	,	22.1-	,,,,,	,
1940-41	lı QE	- 6-	4.05	3.82
October November	4.85 3.46	5.65 3.85	3.05	2.88
December	2.75	2.93	3.55	3.35
January	1.81	1.70	4.30	4.06
February	2.09	2.07	1.12	1.06
March	2.85	3.05	2.88	2.72
April	2.85	3.06	3.44	3.24
May	4.73	5.49	4.77	4.50
June	5.58	6.59	6.44	6.07
July	6.34	7.58	7.24	6.83
August	6.12	7.30	6.43	6.07
September	5.45	6.43	5.10	4.81
TOTALS	48.88 ^c	55.70	52.37 ^d	49.41

ESTIMATES OF MONTHLY EVAPORATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57^a (continued)

In Inches

Season	: Sutherland :	Pamo Reservoir	:San Pasqual : Reservoir	. Uodasa
and month	: Reservoir :	site ^b	: Reservoir	: Hodges : Reservoir
	1100011011	2200	0200	· IICOCI VOII
1941-42				
October	4.30	4.93	3.68	3.47
November	3.69	4.14	3.03	2.86
December	2.46	2.55	1.38	1.30
January	2.64	2.78	1.68	1.59
February	2.63	2.76	1.91	1.80
March	6.78	5.79	2.98	2.81
April	3.25	3.57	2.99	2.82
May June	5.35	6.30	5.47	5.16
July	5.98 6.98	7.12 8.41	6.39 8.13	6.03 7.67
August	6.61	7.93	6.03	5.69
September	5.97	7.10	4.41	4.16
_				
TOTALS	56.62 ^c	63.38	48.08 ^d	45.36
1942-43				
October	5.00	5.84	3.77	3.56
November	4.01	4.56	2.48	2.34
December	3.16	3.46	1.99	1.88
January	2.80	3.00	2.33	2.20
February	2.62	2.75	2.26	2.13
March	2.70	2.87	2.49	2.35
April	3.48	3.87	3.03	2.86
May	5.73	6.79	4.74	4.47
June	6.26	7.48	5.78	5.45
July	6.77	8.13	6.48	6.11
August	6.30	7.53	5.75	5.42
September	6.08	7.25	4.86	4.59
TOTALS	54.91°	63.53	45.96 ^d	43.36
2012 11				
1943-44	l. 75	5.00	2 92	2 63
October November	4.75 4.81	5.22	3.83	3.61 3.56
December	2.31	4.27 2.19	3.77 2.04	3.56 1.92
January	2.64	2.73	1.98	1.87
February	1.99	2.16	2.08	1.96
March	3.67	4.03	3.24	3.06
April	3.95	4.34	3.68	3.47
May	4.57	5.44	4.30	4.06
June	5.03	5.98	4.94	4.66
July	6.59	8.03	6.87	6.48
August	6.95	8,38	7.09	6.69
September	5.74	6.86	4.87	4.59
TOTALS	53.00°	59.63	48.69 ^d	45.93
	75,000	77.05	10.07	. , , , , ,

ESTIMATES OF MONTHLY EVAPORATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57^a (continued)

In Inches

	: :	Pamo	: San Pasqual	:
Season	: Sutherland :	Reservoir	: Reservoir	: Hodges
and month	: Reservoir :	site ^b	: site	: Reservoir
1944-45				
October	4.65	5.22	3•75	3.54
November	2.78	3.22	3.17	2.99
December	2.87	3.08	2.69	2.54
January	2.68	2.75	1.44	1.36
February	2.64	2.31	2.26	2.13
March	2.14	4.65	2.79	2.63
April	5.35	5.07	4.44	4.19
May	5.19	5.93	5.95	5.61
June	4.99	5.63	5.55	5.23
July	5.93	7.28	6.77	6.39
August	5.40	5.61	6.23	5.88
September	5.62	6.47	6.56	6.19
TOTALS	50.24 ^c	57.22	51.60 ^d	48.68
1945-46				
October	4.66	5.22	4.77	4.50
November	3.93	4.03	3.81	3.60
December	2.67	2.77	2.86	2.70
January	3.07	2.89	2.44	2.30
February	2.93	2.72	2.86	2.70
March	3.25	3.24	3.39	3.20
April	3.93	4.16 5.48	3.39	3.20
May June	4.78 6.21	7.31	4.56 7.10	4.30 6.70
July	6.17	7.40	7.10	6.70
August	6.42	7.76	7.10	6.70
September	5.88	6.87	6.25	5.90
-				
TOTALS	53.90°	59.85	55.65 ^d	52.50
1946-47			. 0	1
October	4.62	5.14	3.85	4.67
November	2.99	3.11	2.38	2.74
December	2.44	2,29	1.42	3.58
January February	3.16 2.83	3.01 2.73	2.32 2.10	2.49 2.14
March	2.03 3.34	3.52	3.69	3.36
April	4.65	5.38	5.04	4.78
May	5.54	6.40	5.87	5.61
June	5.89	6.99	6.76	6.30
July	7.91	9.24	9.02	8.14
August	6.72	7.94	7.63	7.41
September	5.91	7.08	6.30	5.94
TOTALS	56.00°	62.82	56.39	57.16

ESTIMATES OF MONTHLY EVAPORATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57^a (continued)

In Inches

			,	
C	· Contract on 3	: Pamo	: San Pasqual	
Season and month	: Sutherland : Reservoir	h	Reservoir : site	: Hodges : Reservoir
and month	: Reservoir	; sice	, 5166	. Reservoir
1947-48		1		
October	4.44	5.00	4.11	4.25
November	3.49	3.69	2.75	3.31
December	2.52	2.62	2.63	3.16
January	3.16	3.36	2.94	1.39
February	2.66	2.90	2.66	2.55
March	3.10 4.28	3·39 4.85	3.47	3.24 4.62
April May	5.52	6.71	5.07 6.47	6.03
June	5.42	6.59	6.62	5.99
July	6.84	8.76	8.50	7.75
August	6.20	7.78	7.75	6.58
September	5.94	7.23	7.50	5.46
TOTALS	53 · 57°	62.88	60.47	5 ⁴ · 33
	23.21	02.00	00.47	24.23
1948-49	2.01	1 70	0.07	0.00
October	3.94 4.09	4.73 4.96	3.87 3.85	3·99 4·30
November December	2.38	2.59	1.85	1.78
January	2.14	2.07	1.29	1.56
February	2.06	1.97	1.70	1.43
March	2.91	3.24	3.15	1.21
April	4.04	4.83	4.58	4.01
May	4.81	5.58	5.31	5.06
June	6.19	7.39	6.99	6.62
July	6.61	8.14	7.38 6.66	6.99
August September	6.73 5.92	8 . 23 6.91	6.22	7.35 6.26
_	SHOOT SECTIONS	COMMUNICATION CO		manufacture and a second
TOTALS	51.82°	60.64	52.85	50.56
1949-50				
October	4.84	5.47	4.49	5.20
November	3.93	4.06	3.55	3.77
December	2.79	2.79	2.11	2.57
January	2.20	2.05	2.50	1.76
February	2.47	2.32	1.21	1.74
March	3·53 4.09	3.82 4.78	3.44 4.13	3.44 4.03
April May	4.86	5.84	5.40	5.00
June	6.26	7.65	6.93	6.49
July	6.54	8.26	7.79	6.96
August	5.92	7.73	8.82	6.80
September	5.04	6.33	5.57	5.22
TOTALS	52.47 ^c	61.10	55.94	52.98
101.200	70011	02.020	1707	7 7-

ESTIMATES OF MONTHLY EVAPORATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57^a (continued)

In Inches

	•	Pamo	: San Pasqual	•
Season	: Sutherland :	Reservoir	: Reservoir	: Hodges
and month	: Reservoir :	site ^b	: site	: Reservoir
1950-51		,		
October	4.55	4.91	5.04	3.15
November	3.05	3.88	3.48	2.75
December	2.61	2.70	2.47	2.01
January	2.02 2.08	1.95 2.13	2.33 2.01	1.72 1.91
February March	3.43	4.07	4.71	3.86
April	3.05	3.17	3.85	2.40
May	4.35	5.10	5.65	5.13
June	5.41	6.37	6.90	5.84
July	6.13	7.33	7.91	6.65
August	5.54	6.51	8.01	6.02
September	4.49	6.11	5.82	4.85
TOTALS	46.71 ^c	54.23	58.18	46.29
1951~52				
October	4.04	4.29	4.66	1.02
November	2.61	2.69	2.88	2.64
December	1.77 1.60	1.57 1.24	1.15 1.58	1.54 1.16
January February	2.31	2.27	1.85	2.10
March	2.11	2.15	2.75	2.02
April	2.49	2.69	3.31	2.61
May	4.63	5.80	5.91	5.29
June	4.90	6.01	6.14	5.02
July	6.03 6.16	7.42 7.44	7.55 7.44	6.17 6.18
August September	5.85	6.60	6.10	5.29
-				41.04
TOTALS	44.50°	50.17	51.32	41.04
1952-53	4.60	4.92	4.16	3.70
October November	2.88	2.90	3,46	2.16
December	1.93	1.86	1.93	1.42
January	2.19	2.21	2.29	1.62
February	2.81	3.09	2.52	2.66
March	3.03	3.48	4.58	3.36
April	3.34	3.80	4.13	3.55
May	4.90	6.11	6.05 7.48	5.72 5.50
June July	5.37 6.18	6.30 7.71	7.66	5.50 6.22
August	6.07	7.10	6.83	6.02
September	5.41	6.11	5.79	5.06
TOTALS	48.71°	55.59	56.88	46.99
202.220	.5.12	11-11	, , , , ,	

ESTIMATES OF MONTHLY EVAPORATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57^a (continued)

In Inches

****	0 0	Pamo	: San Pasqual	0
Season	: Sutherland :	Reservoir	: Reservoir	: Hodges
and month	: Reservoir :	siteb	: site	: Reservoir
1953-54				
October	5.01 ^c	5.60	6.24	4.59
November	3.21c	3.38	3.75	2.76
December	3.51c	3.74	3.14	2.81
January	1.88 ^c	1.69	3.13	1.33
February	3.02c	3.18	3.61	3.27
March	2.34c	2.28	4.90	2.62
April	3.26°	3.54	4.00	3.19
May	4.48°	4.79	5.30	4.17
June	5.05 ^c	5.97	6.90	5.07
July	5.85°	6.91	7.32	5.34
August	5.69°	6.62	7.21	5.30
September	<u>5.84</u>	6.24	5.95	4.64
TOTALS	49.14	53 • 94	61.45	45.09
1954-55				
October	4.47	4.54	4.37	3,21
November	2.83	2.95	3.08	2.18
December	2.26	2.23	2.46	1.94
January	2.42	2.03	1.85	1.06
February	2.46	2.42	2.98	2.06
March	3.37	3.59	4.55	3.06
April	3.74	4.32	5.55	3.98
May	3.82	4.12	5.71	3.48
June	5.65	5,98	6.64	4.85
July	6.14	6.60	7.87	5.44
August	6.06	6.44	7.38	5.10
September	5.78	6.29	5.45	4.70
TOTALS	49.00	51.51	57.89	41.06
1955-56	+9.00	71071	7,1007	12000
October	3.92	3.98	4.02	2.65
November	2.75	3.01	2.99	2.04
December	1.54	1.70	1.58	1.11
January	2.11	1.77	1.44	0.93
February	1.86	1.95	1.94	1.58
March	3.17	3.72	4.26	3.12
April	3.30	3.31	4.21	2.93
May	4.30	4.83	6.41	4.30
June	5•75	6.34	7.22	5.34
July	6.58	7.10	8.49	5.65
August	6.15	6.64	7.71	5.37
September	5.64	6.39	7.36	4.98
			•	
TOTALS	47.07	50.74	57.63	40.00

ESTIMATES OF MONTHLY EVAPORATION AT SELECTED SITES IN SAN DIEGUITO RIVER WATERSHED FOR THE PERIOD 1936-37 THROUGH 1956-57^a (continued)

In Inches

			. O. D	
	•	: Pamo	: San Pasqual	
Season	: Sutherland	: Reservoir	: Reservoir	: Hodges
and month	: Reservoir	: site ^b	: site	: Reservoir
1956-57				
October	3.46	3.76	4.30	3.00
November	4.39	4.43	4.98	3.49
December	2.94	3.13	3.94	2.28
January	1.29	1.13	1.80	0.91
February	1.74	1.63	1.82	1.18
March	2.49	2.77	3.26	2.35
April	3.15	3.81	4.29	3.10
_	•	3.73	5.18	3.92
May	3·55 5.62	6.20	6.94	5.22
June				6.00
July	6.87	7.44	8.10	
August	5.98	6.78	7.29	5.16
September	4.88	<u>5.76</u>	6.16	4.11
TOTALS	46.36	50.57	58.06	40.72

- a. Values shown are based on pan records adjusted to represent conditions of evaporation from large bodies of water.
- b. Estimated from measured values of evaporation at Sutherland and San Vicente Dams.
- c. Estimated from measured values of evaporation at El Capitan Dam.
- d. Estimated from measured values of evaporation at Hodges Dam.

APPENDIX J

RESULTS OF SUBSURFACE EXPLORATION AND SOIL TESTS AT DAM AND RESERVOIR SITES IN SAN DIEGUITO RIVER WATERSHED

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APPENDIX J

TABLE Jol

RESULTS OF SOIL TESTS AT DAM AND RESERVOIR SITES IN SAN DIEGUITO RIVER WATERSHED

Lowarian of sample Section, Township, sand Renge ss	Depth below ground surface,	12 12 38°1:	3/4 : 1n. : 1n. :	0al an 3/8 : 1n. : Gr	Mechanical analysis, in per ; 3/4; 3/8; No.; No.; No.; No.; in.; in.; in.; in.; in.; in.; in.; in	38 ε 1 ε 2 ε 3 ε 3 ε 3 ε 3 ε 3 ε 3 ε 3 ε 3 ε 3	r cent 0. : No 16 : .	ant finer by 8 No. 1 No. 50 11 Master 8 0 0 59:0.29		reight No. : 200 :mic	. 5	Atterberg	Specific	: : : : : : : : : : : : : : : : : : :	: Optimum: Perme: mois- :ability : ture, :maximu : in :densit; : per :in fee	> B & S S	at: Angle of : ilnternal : ifriction; in in : degrees :	Cohesiens in tons per square fout
									2	PAMO SITE	題							
Potential Borrow Area																		
SE. 4 SW. 4 Sec. 2, T. 125, R. 1E., S. B. B. &M.	14.0	0	<u>a</u> 0	1	100	96	93	%	79	¥		Nonplastie	2.71	119.4	11.7	00.001	*	0
SE.\$\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	0°9	B 0	0 0	0	100	98	蒙	80	29	33	-	Nonplestic	20,74	122.6	10.8	0°002	35°1 ^b	1°0°
SW. \$\delta_p SW. \$\delta_p Sec. 14\gamma_p \text{Tollow 125.9} S. B. 1E. \gamma_p S. B. B. & M.	10.0	2 8	9	0	98	袁	87	73	×	33	1 0	Nonplastic	2.74	122.8	10.5	0.01	42°3p	0.28 ^b
NE.4; NW.4; Sec. 23; T.12S.; R.1E.; S.B.B.&M.	3.0	Q 6	0 0	0	\$		09	31	10	0	0	Nonplastic	2.78	108.0	17.5	52	0	9
									SAN	SAN PASQUAL	LSTE							
Potential Borrow Area																		
NW.4, SW.4, Sec. 6, T.13S., R.1W., S.B.B.&M.	10.0	g 8	0	ů ů	100	Ж	88	表	09	2	8	Nonplastic	2,64	125.8	9.5	0.007	0 6	0
SWoto NEOTO Sec. 19 TolySo, Rolwo, Sobeberom	2°0	Q 8	0	1 0	100	26	ま	87	東	38	6	Nonplastic	2.75	129.0	9.5	0.0025	3 0	0 8
SE.4. SW.4. Sec. 29, T.12S., R.1W., S.B.B.&M.	15.0	1	8	0	300	98	95	%	73	42	D	Nonplastic	2.79	130.6	6°6	00.001	36.3b	qZħ°O
SW.4, SW.4, Sec. 31, T.12S., R.1W., S.B.B.&M.	0°4	i	0	0	86	95	78	P	30	0	0	Nonplastie	2.75	7°66	9	39	0	0

RESULTS OF SOIL TESTS AT DAM AND RESERVOIR SITES IN SAN DIEGUITO RIVER WATERSHED (continued)

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Location of sample	910	•••		10	· Optimum	Optimum: rerme-	Singer Page	
	: Depth	: Mechanical analysis, in per cent finer by weight :		: Maximum	-elou:	:ability an	Maximum smels- :ability at: Angle of :Coheston,	Lon
Section. Township.	: below	: 13 : 3/4 : 3/8 : No. : No. : No. : No. : No. : No.	Atterberg	:Specificadensity,	ture,	: meximum	sinternal : in to	sus
and Range	:ground	ground : in. : in. : in. : h : 8 : 16 : 30 : 50 : 200 :microns: limits : gravity: in pounds: in :density, :frietion,: per	limits	: gravity:in pounds	. In	:density,	:frietion,: per	
)	:surface,:	Grain size, in millimeters		: : ber cubie: per	aed:	:In feet	: in : square	® 2
	: in feet	38.1: 1		: Loofa	s cent	:per day	foot : cent : per day : degrees : foot	an l

SAN PASQUAL SITE (continued)

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	Nonplastic	Nonplastie	Nonplastic	Nonplastie	Nonplastie	Nonplastic	Nonplastie	Nonplastic	Nonplastie	Nonplastic	Nonplastic	
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	66	100	73	89	27	78	88	73	ま	夫	83	
	100	ł	87	35	87	ま	32	88	66	35	35	
	100	B B 0	ま	82	100	100	66	35	100	24	95	
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	, R.2W., S.B.B.&M. 23.0-24.0	33.0-34.0	53.5-55.0	75.1-75.5	75.5-76.0	76.0-76.5	76.5-77.0	77.0-77.5	77.5-77.9	83.7-84.3	84.3-84.8 100 96 95 92	
E.4, Sec. 1	R.2W., S.E											

a. Sample compacted at optimum moisture. b. Computed by direct shear test. 6. Computed by triaxial shear test.

TABLE J-2

LOGS OF EXPLORATORY HOLES AT SAN PASQUAL DAM SITE IN SAN DIEGUITO RIVER WATERSHED

Test Hole Number: 1

State Location Number: 13S/1W-6N3

Elevation of Ground Surface: 333 feet, U.S.G.S. datum

Date Completed: February 1, 1958

Depth interval, : in feet :	Material
0- 1	Sandy soil.
1- 22	Brown sand, medium to fine.
22- 41	Tan sand, medium to fine.
41- 56	Tan sand, medium to coarse.
56- 61	Tan sand, medium to coarse, some gravel.
61- 65	Tan sand, medium to coarse.
65 71	Tan sand, medium to coarse, some gravel.
71- 81	Tan sand, medium to coarse.
81- 84	Tan sand, medium to coarse, some gravel.
84= 86	Tan sand, medium to coarse.
8 6 ∞ 8 7	Tan sand, medium to coarse, some gravel.
87–117	Fractured and weathered granodiorite, 81% core recovery.

LOGS OF EXPLORATORY HOLES AT SAN PASQUAL DAM SITE IN SAN DIEGUITO RIVER WATERSHED (continued)

Test Hole Number: 2

State Location Number: 13S/2W-1Ll

Elevation of Ground Surface: 445 feet, U.S.G.S. datum

Date Completed: February 10, 1958

Depth interval, in feet	Material
0- 2	Top soil, red wash water.
2- 6	Soft decomposed granite, red wash water.
6- 14	Firm decomposed granite, red wash water.
14- 31	Firm decomposed granite, brown wash water.
31- 32	Solid decomposed granite, brown wash water.
32- 45	Firm decomposed granite, brown wash water.
45- 46	Clayey decomposed granite, brown wash water.
46- 54	Firm decomposed granite, brown wash water.
54- 60	Solid decomposed granite, brown wash water.
60- 88	Hard decomposed granite, brown wash water.
88-100	Badly weathered crumbly tonalite, 8% core recovery.

LOGS OF EXPLORATORY HOLES AT SAN PASQUAL DAM SITE IN SAN DIEGUITO RIVER WATERSHED (continued)

Test Hole Number: 3

State Location Number: 13S/2W-1R2

Elevation of Ground Surface: 395 feet, U.S.G.S. datum

Date Completed: February 15, 1958

Depth interval, : in feet :	Material
0- 2	Top soil, red water.
2- 4	Soft decomposed granite, red water.
4- 8	Soft decomposed granite, brown water.
8-17	Firm decomposed granite, brown water.
17-18	Rock.
18-25	Firm decomposed granite, brown water.
25-29	Solid decomposed granite, brown water.
29–31	Firm decomposed granite, brown water.
31-35	Hard decomposed granite, brown water.
35 ~55	Weathered and fractured transition zone between granodiorite and tonalite, 70% core recovery.

TABLE J-3

RESULTS OF WATER TESTS AT SAN PASQUAL DAM SITE IN SAN DIEGUITO RIVER WATERSHED

Flow Tests

Test hole number	<pre>: Depth : : interval, : : in : : feet :</pre>	Water pressure, in pounds per square inch	: Water loss, : in gallons : per : minute	Duration of test, in minutes
1	97-107	52 80 100	6.7 8.3 9.8	14 14 14
	107-117	65 120 80	8.1 11.7 6.8	14 14 14
2	90-100	75 100 55	8.0 12.7 8.6	14 14 14
3	35–45	50 80 105 75 55	0.8 2.1 4.3 3.8 2.6	14 14 14 14 14
	45-55	60 90 80 115 80 55	1.2 3.1 2.8 5.0 2.1 1.6	14 3 11 14 14

RESULTS OF WATER TESTS AT SAN PASQUAL DAM SITE IN SAN DIEGUITO RIVER WATERSHED (continued)

Holding Tests

Test hole number	: Depth : interval, : in : feet	: Time, : in : seconds	: : : Tr		ter pressur in per square Trial 2 :	
1	107-117	0 15 30 45 60		65 10 4 0	120 30 15 7 5	80 15 5 3 0
3	35–45	0 15 30		55 0	75 5 0	100 5 0
	45-55	0 15 30 45 60		75 60 45 30	85 57 43 33 20	600 600 600 600 600 600 600 600 600 600 600

RESULTS OF WATER TESTS AT SAN PASQUAL DAM SITE IN SAN DIEGUITO RIVER WATERSHED (continued)

Gravity Test

Test hole number: 2

Depth of hole, in feet: 59

Diameter of hole, in feet: 0.3

	Time :	Depth to water added to	Average water loss in
	: Seconds :		
MINUTES	: Seconds :	. test noie, in leet	garrons per minute
0	0	full	
Ö	20	0.33	.522
Ö	34	0.5	.466
Ö		0.66	.389
	53 10	0.83	•375
1			
1	24	1.0	.377
2	0	1.33	.351
2	34	1.66	.342
3	20	2.0	.317
4	35	2.83	.325
6	2	3.75	.328
6	10	3.92	.336
6	30	4.0	.3 25
6	45	4.25	•332
7	0	4.33	•327
7	30	4.66	.328
8 8 9 9	0	4.92	.325
8	30	5.1	.317
9	0	5•5	•322
9	30	5.75	.320
11		6.7	•322
13	•	7.8	.317
15	65 000	8.8	.310
16	top day	9.3	.307
19	(me/Cc)	10.9	.303
20	CHO emp	11.2	.296
21		11.4	.287
23		11.8	.271
25		11.98	.253
39		13.20	.179
41		13.45	.173
		14.24	.137
55	Own Citing	14.24	•±51

APPENDIX K
ESTIMATES OF COSTS

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ESTIMATES OF COSTS

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	Inter-Departmental Communication, Dated July 2, 1958, Substantiating the Choice of the Route North of San Pasqual Valley Rather Than the Previously Recommended Route Through Green Valley for Relocation of State Sign Route No. 78 as a Result of Construction of Potential Reservoirs at the San Pasqual Site	K-67
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ESTIMATED COST OF LAND AND IMPROVEMENTS FOR SAN PASQUAL-MAIN LAKE HODGES BASIN GROUND WATER DEVELOPMENT

GENERAL FEATURES

Area of ground water basin, in acres	4,630	
Land necessary for project, in acress Owned by City of San Diego Privately-owned	6,220 3,620	
Total	9,840	
Number of privately-owned parcels	70	
CAPITAL COSTS		
Property owned by City of San Diego* Land Improvements Privately-owned property* Land Improvements Acquisition Subtotal Contingencies, 15%	\$1,828,500 351,000 1,024,200 1,397,000 70,000	\$2,179,500 2,491,200 \$4,670,700 700,600
PROJECT TOTAL		\$5,371,300
ADDITIONAL COST TO CITY OF SAN DIEGO		(1),0 (1)
Privately-owned property Contingencies, 15%		\$2,491,200 <u>373,700</u>
TOTAL		\$2,864,900

^{*} Includes excess lands and improvements which are outside of the San Pasqual-Main Lake Hodges Basin that would probably be acquired in lieu of payment of severance damages due to reducing the parcel to less than an economic unit or reducing the use of the land to an amount lower and less desirable than that now enjoyed.

ESTIMATED COSTS OF WELLS, PUMPING PLANTS AND CONVEYANCE FACILITIES AT SAN PASQUAL-MAIN LAKE HODGES BASIN TO PRODUCE A SEASONAL YIELD OF 3,200 ACRE-FEET

Maximum storage capacity utilized: 13,700 acre-feet Average depth to ground water at maximum basin depletion: 28 feet

OUT THEOREM, BOLL WHILE HE'S SHANK THAN THE THEORY SHANK THE COMMISSION OF THE COMMI	-co-della ma				
	000	Quantity	<pre>% Unit % price</pre>	8	Cost
CAPITAL COSTS					
Wells, pumps and motors				(no additi	onal cost)a
Pipe Steal, concrete coated, mortalined, furnish and install 12-gage 6-in. diam. 12-gage 8-in. diam. 12-gage 10-in. diam. 12-gage 12-in. diam.	ł Iº	4,000 lin.ft. 6,200 lin.ft. 13,000 lin.ft. 4,300 lin.ft.	2.50 3.20	15,500 h1,600	\$ 81,500
Valves			lump sum	7,700	7,700
Meters, Sparling			lump sum	4,700	4,700
San Pasqual Basin-Lake Hodges Canal Excavation, unclassified Embankment Trimming Concrete lining Culverts		27,300 cu.yd. 23,200 cu.yd. 40,400 sq.yd. 2,850 cu.yd.	0.50 0.40 0.75 25.00 lump sum	9,300 30,300 71,300	136,600
Bridges, farm road access		10 each	1,200.00	12,000	12,000
Fence, 4-strand barbed wire, both sides of canal.		27 miles	2,500.00	67,500	67,500
Siphons Excavation, unclassified Backfill, compacted Backfill, consolidated Pipe, steel, mortar lined, concrete coated, furnish		15,600 cu.yd. 650 cu.yd. 8,750 cu.yd.	0.50 3.00 0.75	2,000	
and install 22-inch I.D. 16-inch I.D. Inlet and outlet structure Subtotal		5,100 lin.ft. 1,600 lin.ft.		9,800	72,800 \$ 382,800

ESTIMATED COSTS OF WELLS, PUMPING PLANTS AND CONVEYANCE FACILITIES AT SAN PASQUAL-MAIN LAKE HODGES BASIN TO PRODUCE A SEASONAL YIELD OF 3,200 ACRE-FEET (continued)

Item	0 0	Quantity	:	Unit price	*	Cost
Administration and engineer	ing, 10%					\$ 38,300
Contingencies, 15%						57,400
Real estate ^b						5,371,300
Subtotal						\$5,849,800
Interest during construction construction period	on, 4% for	one-half of	l-y∈	ar		117,000
TOTAL						\$5,966,800
ANNUAL COSTS						
Interest, 3.5%						\$ 208,800
Amortization, 40-year sinki	ng fund a	t 3.5%				70,600
Operation and maintenance,	-1					6,000
Electric energy for pumping	3					12,600
TOTAL						\$ 298,000

a. It is assumed that the existing wells, and pumping facilities purchased as part of the lands and improvements would be used in producing the present seasonal yield of 3,200 acre-feet and that no new wells or pumping facilities would be needed.

b. Detail costs of land, improvements, and acquisition are presented in Table K-1.

ESTIMATED COSTS OF WELLS, PUMPING PLANTS AND CONVEYANCE FACILITIES AT SAN PASQUAL-MAIN LAKE HODGES BASIN TO PRODUCE A SEASONAL YIELD OF 4,800 ACRE-FEET

Maximum storage capacity utilized: 27,000 acre-feet Average depth to ground water at maximum

basin depletion: 48 feet

Item S		<pre>% Unit % price</pre>	8	Cost 🧢
CAPITAL COSTS				
Wells (new) ^a Drill, case, perforate, gravel pack and develop 2 new wells, diameter 16-in.	315 lin.	ft. \$ 33.00	\$10 ₂ 400	\$ 10 ₉ 400
Pumps (new) ^a Motor, deep well turbine pump, furnish and install 40 HP 30 HP	l each l each		5,200 <u>4,800</u>	10,000
Pipe Steel, concrete coated, mortar lined, furnish and install 12-gage 6-in. diam. 12-gage 8-in. diam. 12-gage 10-in. diam. 12-gage 12-in. diam.	4,000 lin. 7,600 lin. 13,100 lin. 5,900 lin.	ft. 2.50 ft. 3.20	7,600 19,000 41,900 23,000	91,500
Valves		lump sum	8,200	8,200
Meters, Sparling		lump sum	5,400	5,400
San Pasqual Basin-Lake Hodges				
Canal Excavation, unclassified Embankment Trimming Concrete lining Culverts	28,800 cu.y 24,500 cu.y 43,400 sq.y 3,100 cu.y	d. 0.40 d. 0.75	14,400 9,800 32,600 77,500 12,000	146,300
Bridges, farm road access	10 each	1,200.00	12,000	12,000
Fence, 4-strand barbed wire, both sides of canal	27 mîle	es 2,500.00	67,500	. 67,500
Siphons Excavation, unclassified Backfill, compacted Backfill, consolidated	16,800 cu.y 820 cu.y 9,500 cu.y	d. 3.00	8,400 2,500 7,100	

ESTIMATED COSTS OF WELLS, PUMPING PLANTS AND CONVEYANCE FACILITIES AT SAN PASQUAL-MAIN LAKE HODGES BASIN TO PRODUCE A SEASONAL YIELD OF 4,800 ACRE-FEET (continued)

	0		0	Unit	00			
Item	ô	Quantity	8	price	0		Cost	
CAPITAL COSTS								
Pipe, steel, mortar lined, concrete coated, furnish and install 26-inch I.D. 20-inch I.D. Inlet and outlet structure Subtotal		5,100 lin.ft. 1,600 lin.ft.		11.35 7.50 lump sum		\$57,900 12,000 3,800	\$ 91,700 \$ 443,000	-
Subtotal								
Administration and engineering,	10%						山,300	
Contingencies, 15%							66,400	
Real estate ^b							5,371,300	
Subtotal							\$5,925,000	
Interest during construction, 4 construction period	% for	one-half of l-	уe	ar			118,500	
TOTAL		- year-son - close-Ciline - soler close-Ciline - Soler					\$6,043,500	
ANNUAL COSTS								
Interest, 3.5%							\$ 211,500	
Amortization, 40-year sinking f	und a	t 3.5%					71,500	
Operation and maintenance							6,000	
Electric energy for pumping							17,300	
TOTAL							\$ 306,300	
			EUROPE					

as Costs based on assumption that 2 new wells, pumps and motors would be needed in addition to the existing equipment purchased with lands and improvements. Cost of existing wells and pumping equipment included in the value for real estate.

b. Detail costs of land, improvements, and acquisition are presented in Table K-1.

ESTIMATED COSTS OF WELLS, PUMPING PLANTS AND CONVEYANCE FACILITIES AT SAN PASQUAL-MAIN LAKE HODGES BASIN TO PRODUCE A SEASONAL YIELD OF 6,000 ACRE-FEET

Maximum storage capacity utilized: 41,000 acre-feet Average depth to ground water at maximum basin depletion: 71 feet

	<u> </u>		9 1	Unit	00			
	Quant	city		price	0		Co	st
CAPITAL COSTS								
Wells (new)a Drill, case, perforate, gravel pack and develop 6 new wells, diameter 16-in.	760	lin.ft.	\$	33.00		\$25,100	\$	25,100
Pumps (new) ^a Motor, deep well turbine pump, furnish and install 20 HP 25 HP 30 HP 40 HP	2 2	each each each each	3 4	,100.00 ,500.00 ,800.00		3,100 7,000 9,600 10,400		30,100
Pipe Steel, concrete coated, mortar lined, furnish and install 12-gage 6-in. diam. 12-gage 8-in. diam. 12-gage 10-in. diam. 12-gage 12-in. diam.	10,800 19,700	lin.ft. lin.ft. lin.ft.		1.90 2.50 3.20 3.90		7,600 27,000 63,000 32,800		130,400
Valves			ŀ	ump sum		10,000		10,000
Meters, Sparling			1:	ump sum		7,100		7,100
San Pasqual Basin-Lake Hodges Canal								
Excavation, unclassified Embankment Trimming Concrete lining Culverts	25,600 47,000	cu.yd. cu.yd. sq.yd. cu.yd.	1·	0.50 0.40 0.75 25.00 ump sum		15,000 10,200 35,300 82,500 12,000		155,000
Bridges, farm road access	10	each	1	,200.00		12,000		12,000
Fence, 4-strand barbed wire both sides of canal	27	miles	2	,500.00		67,500		67,500
Siphons Excavation, unclassified	17,600	cu.yd.		0.50		8,800		

ESTIMATED COSTS OF WELLS, PUMPING PLANTS AND CONVEYANCE FACILITIES AT SAN PASQUAL-MAIN LAKE HODGES BASIN TO PRODUCE A SEASONAL YIELD OF 6,000 ACRE-FEET (continued)

Item	Quantity	: Unit :		Cost
CAPITAL COSTS				
Backfill, compacted Backfill, consolidated Pipe, steel, mortar lined, concrete coated, furnish and install	900 cu.yd. 12,100 cu.yd.		\$ 2,700 9,100	
28-inch I.D. 22-inch I.D. Inlet and outlet structure	5,100 lin.ft. 1,600 lin.ft.		62,000 13,500 4,000	\$ 100,100
Subtotal				\$ 537,300
Administration and Engineering	, 10%			53,700
Contingencies, 15%				80,600
Real Estate ^b				5,371,200
Subtotal				\$6,042,800
Interest during construction, l	#% for one-half of l	-year		120,900
TOTAL				\$6,163,700
ANNUAL COSTS				
Interest, 3.5%				\$ 215,700
Amortization, 40-year sinking		72,900		
Operation and maintenance		6,500		
Electric energy for pumping				21,000
TOTAL				\$316,100

a. Costs based on assumption that 6 new wells and 7 new pumps and motors would be needed in addition to the existing equipment purchased with lands and improvements. Cost of existing wells and pumping facilities included in the value for real estate.

b. Detail costs of land, improvements, and acquisition are presented in Table K-1.

ESTIMATED COST OF ENLARGEMENT OF SUTHERLAND RESERVOIR TO A STORAGE CAPACITY OF 37,430 ACRE-FEET

(Based on prices prevailing in 1958)

			isting servoir		arged ervoir
Capacity: Elevation of crest of dam: U.S.G.S. datum		29,680 2,074	acre-feet feet	37,430 2,074	acre-feet feet
Elevation of crest of spillwa	y:	2,057	feet	2,057	feet
U.S.G.S. datum Elevation of top of spillway U.S.G.S. datum	gates:	**** ****		2,070	feet
Increase in capacity of reser	voir:	(III)	en Carriero (Ser November 1900)	7,750	acre-feet
	° 0	°	Unit	8	C
Item	: Quant	ity :	price	:	Cost
CAPITAL COSTS					
Spillway gates, addition of Radial gates, 3-13 x50 Radial gate hoists, 3	156,000 28,500		\$ 0.55 0.65	\$ 85,800 18,500	
Concrete, reinforced 2 piers, intermediate	900	cu.yds.	50.00	45,000	
Bridge and rail	240	cu.yds.	60.00	14,400	
Reinforcing steel	182,000	lbs.	0.15	27,300	
Subtotal					\$191,000
Administration and engineering	g, 10%				19,100
Contingencies, 15%					28,600
Interest during construction, construction period.	4% for on	e-half	of 1-year		4,800
TOTAL					\$243,500
ANNUAL COSTS					
Interest, 3.5% Amortization, 40-year sinking Operation and maintenance	fund at 3	.5%			\$ 8,500 2,900 1,000
TOTAL					\$ 12,400

TABLE Kot

ESTIMATED COST OF LAND AND IMPROVEMENTS FOR THREE SIZES OF DAM AND RESERVOIR AT THE PAMO "B" SITE ON SANTA YSABEL CREEK IN SAN DIEGUITO RIVER WATERSHED

Gross reservoir storage capacity.

0	Gross	in acre-feet	capacity,
0	90,000	135,000	: 163,400
GENERAL FEATURES			
Water surface elevation for design flood, in feet, U.S.G.S. datum Land necessary for	1,055	1,081	1,095
project, in acres Owned by City of San Diego Privately-owned	1,490 1,860	1,490 1,860	1,490 1,860
Totals	3,350	3,350	3,350
Number of privately- owned parcels	19	19	19
CAPTIAL COSTS			
Property owned by City of San Diego Land Improvements	\$ 53,000 <u>0</u> \$ 53,000	\$ 53,000 0 \$ 53,000	\$ 53,000 <u>0</u> \$ 53,000
Privately-owned property Land Excess land* Improvements Acquisition	109,000 63,000 82,000 19,000 273,000	123,000 49,000 82,000 19,000 273,000	149,000 23,000 82,000 19,000 273,000
Subtotals	\$326,000	\$326,000	\$326,000
Contingencies, 15%	49,000	49,000	49,000
PROJECT TOTALS	\$375,000	\$375,000	\$375,000
ADDITIONAL COST TO CITY OF	SAN DIEGO		
Privately-owned property Contingencies, 15% TOTALS	\$273,000 _41,000 \$314,000	\$273,000 <u>41,000</u> \$314,000	\$273,000 _41,000 \$314,000

^{*} Excess land is land required to avoid payment of severance damages, or to avoid incurring access road construction costs which would exceed the value of the excess land minus its salvage value.

ESTIMATED COST OF PAMO "B" DAM AND RESERVOIR WITH STORAGE CAPACITY OF 90,000 ACRE-FEET

(Based on prices prevailing in 1958)

Elevation of crest of dam: 1,060 feet, U.S.G.S. datum Elevation of crest of spillway: 1,037 feet Capacity of spillway with 5-foot Height of dam to spillway crest, above freeboard: 83,100 second-feet Height of dam to spillway crest, above stream bed: 187 feet

Capacity of reservoir to crest of spillway: 90,000 acre-feet

	:		: Unit	0	
Item	: Quan	tity	: price	8	Cost
CAPITAL COSTS					
Dam					
Exploration			lump sum	\$ 40,000	
Diversion of stream and					
dewatering of foundat:	ion		lump sum	50,000	
Stripping topsoil	211,200	cu.yd.	0.35	73,900	
Excavation for embankmen					
Foundation	265,900	cu.yd.	0.70	186,100	
Impervious from					
borrow pits	1,258,200	cu.yd.	0.55	692,000	
Random from stream					
bed and borrow					
pits	2,017,800	cu.yd.	0.60	1,210,700	
Embankment					
Impervious	1,094,100	cu.yd.	0.15	164,100	
Random	1,720,700		0.12	206,500	
Random salwage	729,100		0.20	145,800	
Rock riprap	73,600	cu.yd.	2.80	206,100	
Drilling grout holes		lin.ft.		62,400	
Pressure grouting		cu.ft.	3.00	31,200	
Gravel drains	33,900	cu.yd.	3.00	101,700	\$3,170,500
Spillway					
Excavation, unclassified		•	1.50	1,059,500	
Backfill		cu.yd.	1.50	1,500	
Rock riprap	600	cu.yd.	2.80	1,700	
Concrete					
Weir, cutoff and	- 444			/	
flip bucket		cu.yd.	45.00	126,000	
Floor		cu.yd.	40.00	132,000	
Walls		cu.yd.	50.00	35,000	
Reinforcing steel	541,500		0.15	81,200	
Drilling grout holes		lin.ft.		14,400	
Pressure grouting	2,400	cu.ft.	3.00	7,200	1,458,500

ESTIMATED COST OF PAMO "B" DAM AND RESERVOIR WITH STORAGE CAPACITY OF 90,000 ACRE-FEET (continued)

			0	Q+
Item	Quantity	: price		Cost
CAPITAL COSTS				
Outlet Works				
Excavation				
Inlet and outlet		#	# 7 (00	
structures	3,800 cu.yd.		\$ 7,600	
Conduit	5,800 cu.yd.		8,700	
Backfill	3,900 cu.yd.	4.50	17,600	
Concrete		~~ ~~	4	
Pipe encasement	1,620 cu.yd.	/	81,000	
Intake tower	1,090 cu.yd.		65,400	
Reinforcing steel	351,300 lbs.	0.15	52,700	
Miscellaneous				
metalwork	15,000 lbs.	0.45	6,800	
Steel pipe, 30-inch				
dia., intake tower		lump sum	7,900	
Butterfly valves,				
30-inch dia., intake				
tower	5 each	4,000.00	20,000	
Steel pipe, 42-inch dia	. 182,000 lbs.	0.30	54,600	
High pressure slide	•			
gate		lump sum	15,000	
Gate valve, 42-inch dia	. l each	5,000.00	5,000	
Needle valve, 36-inch		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
dia.	1 each	17,000.00	17,000	
Pressure regulators	4 each	2,100.00	8,400	
Venturi meter	4 04011	lump sum	4,100	
Control house		lump sum	5,000	\$ 376,800
Control nouse		Tump bum		¥)/0,000
Reservoir				
Clearing reservoir land	s 1,425 ac.	35.00	49,900	
Road relocation,			-/	
(truck trails)		lump sum	264,000	
Access road		lump sum	150,000	140.000
Caretaker's house and s	hop	lump sum	20,000	483,900
Subtotal				\$5,489,700
Administration and engine	aning 10%			549,000
Contingencies, 15%	erring, row			823,500
Real estate*				375,000
near estate*				575,000
Subtotal				\$7,237,200
Interest during construct	ion. 4% for one-	half of 2-v	ear	
construction period				289,500
tonout docton por rod				
TOTAL				\$7,526,700
40444				#197-49100

ESTIMATED COST OF PAMO "B" DAM AND RESERVOIR WITH STORAGE CAPACITY OF 90,000 ACRE-FEET (continued)

Item	8	Quantity	8	Unit price	•	Cost
ANNUAL COSTS						
Interest, 3.5% Amortization, 40-year Operation and maintena		fund at 3.5%	5			\$ 263,400 89,000
TOTAL						\$ 363,900

^{*} Detail costs of land, improvements and acquisition are presented in Table K=6.

ESTIMATED COST OF FAMO-MIRAMAR COMBUIT TO ACCOMPANY RESERVOIR OF 90,000 ACRE-FEET CAPACITY

(Based on prices prevailing in 1958)

Length of conduit, in miles: 24
Inside diameter of pipe, in inches: 34
Design capacity of pipe, in
second-feet: 25
Average
per
Manning
Hydrau

Cross-sectional area of pipe, in

square feet: 6.28

Average velocity, in feet
per second: 3.96
Manning's value of "n": 0.0115
Hydraulic radius, in feet: 0.708
Hydraulic slope, in feet
per foot: 0.001525

Item	: Quantity	:	Unit price	: -:	C	Cost
CAPITAL COSTS						
Excavation, unclassified Backfill, compacted Backfill, consolidated Pipe, steel, mortar-lined concrete coated, 34-inc I.D.			1.20 3.00 0.75	\$	391,100 68,700 97,100	
10-gage 8-gage 3/16-inch 1/4-inch Manhole Manhole and air valve Manhole and blowoff Vent structure Right of way	116,800 lin.ft 4,700 lin.ft 2,000 lin.ft 3,600 lin.ft 7 each 43 each 26 each 20 each	•	15.00 15.85 17.05 19.70 300.00 460.00 540.00 600.00 mp sum	1	,752,000 74,500 34,100 70,900 2,100 19,800 14,000 12,000 100,000	
Subtotal						\$2,636,300
Administration and engine Contingencies, 15% Interest during construct construction period		hal	f of l-	·year		263,600 395,400 65,900
TOTAL						\$3,361,200
ANNUAL COSTS						
Interest, 3.5% Amortization, 40-year sin Operation and maintenance		%				\$ 117,600 39,800 3.400
TOTAL						\$ 160,800

ESTIMATED COST OF PAMO "B" DAM AND RESERVOIR WITH STORAGE CAPACITY OF 135,000 ACRE-FEET

(Based on prices prevailing in 1958)

Elevation of crest of dam: 1,086 feet, U.S.G.S. datum

Elevation of crest of spillway: 1,064 feet Height of dam to spillway crest, above

stream bed: 21% feet.

Capacity of reservoir to crest of spillway: 135,000 acrefeet

Capacity of spillway with 5-foot freeboard: 78,500 second-feet

stream bed: 214 feet		fre	eboard: 78,	500 se c ond-feet
Item	: Quantity	: Unit : price :		ost
CAPITAL COSTS				
Dam				
Exploration		lump sum	\$ 50,000	
Diversion of stream an	d			
dewatering of founda	. –			
tion		lump sum	50,000	
Stripping topsoil	254,500 cu.yd.	\$ 0.35	89,100	
Excavation for embank-	,			
ment		. ~.	-14 -00	
Foundation	354,600 cu.yd.	0.70	248,200	
Impervious from	3 700 700 1	0.55	070 100	
borrow pits	1,780,700 cu.yd.	0.55	979,400	
Random from stream bed and				
borrow pits	3,100,900 cu.yd.	0,60	1,860,500	
Embankment	J,100,700 Gu.yu.	0,00	1,000,000	
Impervious	1,548,400 cu.yd.	0.15	232,300	
Random	2,696,400 cu.yd.	0.12	323,600	
Random salvage	723,300 cu.yd.	0.20	144,700	
Rock riprap	91,400 cu.yd.	2.80	255,900	
Drilling grout holes	17,900 lin.ft.		71,600	
Pressure grouting	12,000 cu.ft.	3.00	36,000	
Gravel drains	56,600 cu.yd.	3.00	169,800	\$4,511,100
Spillway				
Excavation,				
unclassified	606,300 cu.yd.	1.50	909,500	
Backfill	1,000 cu.yd.	1.50	1,500	
Rock riprap	410 cu.yd.	2.80	1,100	
Concrete				
Weir, cutoff, and flip bucket	2 750 00	45.00	123,800	
Floor	2,750 cu.yd. 3,410 cu.yd.	40.00	136,400	
Walls	740 cu.yd.	50,00	37,000	
Reinforcing steel	552,700 lbs.	0.15	82,900	
Drilling grout holes	3,600 lin.ft.		14,400	
Pressure grouting	2,400 cu.ft.	3.00	7,200	1,313,800

ESTIMATED COST OF PAMO "B" DAM AND RESERVOIR WITH STORAGE CAPACITY OF 135,000 ACRE-FEET (continued)

Item	00	Quantity	8	Unit :		(Cost
		- Controlley			-		
CAPITAL COSTS							
Outlet Works							
Excavation							
Inlet and outlet							
structures		3,100 cu.yd.			\$	6,200	
Conduit		7,600 cu.yd.		1.50		11,400	
Backfill		4,900 cu.yd.		4.50		22,100	
Concrete				~o oo		300 500	
Pipe encasement		2,050 cu.yd.		50.00		102,500	
Intake tower		1,260 cu.yd.		60.00		75,600	
Reinforcing steel		430,300 lbs.		0.15		64,500	
Miscellaneous		15 000 1ha		0.45		6,800	
metalwork Steel pipe, 30-inch		15,000 lbs.		0.4)		0,000	
dia., intake tower				lump sum		8,700	
Butterfly valves,				Lump Jum		0,,00	
30-inch dia.		5 each).	4,000.00		20,000	
Steel pipe, 48-inch d	ia.	•	~	0.30		83,700	
High pressure slide		2,09,00 200					
gate				lump sum		21,000	
Gate valve, 48-inch d	ia.	l each		6,000.00		6,000	
Needle valve, 36-inch		. l each	1	7,000.00		17,000	
Pressure regulators		4 each		2,100.00		8,400	
Venturi meter				lump sum		4,100	
Control house				lump sum		5,000	\$ 463,000
Reservoir							
Clearing reservoir la	nds	1,862 ac.		35.00		65,200	
Road relocation		·					
(truck trails)				lump sum		264,000	
Access road, Pamo gra	de			_			
to dam				lump sum		150,000	100,000
Caretaker®s house and	sho	p		lump sum	-	20,000	499,200
Subtotal							\$6,787,100
Administration and engi	neer	ing, 10%					678,700
Contingencies, 15%							1,018,100
Real estate*							375,000
Subtotal							\$8,858,900
Descour							
Interest during constru	ctic	on, 4% for one-	-ha]	f of 2-y	ear		
construction period							354,400
							#- 0
TOTAL							\$9,213,300

ESTIMATED COST OF PAMO "B" DAM AND RESERVOIR WITH STORAGE CAPACITY OF 135,000 ACRE-FEET (continued)

9		0	Unit	:	
8	Quantity	8	price	8	Cost
sinki	ng fund at 3	3 . 5%			\$322,5 00 109, 000
nce					14,600
					\$446,100
	sinki	sinking fund at 3	<pre>2 Quantity : sinking fund at 3.5%</pre>	<pre>s Quantity : price sinking fund at 3.5%</pre>	<pre>s Quantity : price : sinking fund at 3.5%</pre>

^{*} Detail costs of land, improvements, and acquisition are presented in Table K-6.

ESTIMATED COST OF PAMO-MIRAMAR CONDUIT TO ACCOMPANY RESERVOIR OF 135,000 ACRE-FEET CAPACITY

(Based on prices prevailing in 1958)

Length of conduit, in miles: 24
Inside diameter of pipe, in inches: 36
Design capacity of pipe, in
second-feet: 29
Cross-sectional area of pipe, in

square feet: 7.07

Average velocity, in feet per second: 4.13 Manning's value of "n": 0.0115 Hydraulic radius, in feet: 0.75 Hydraulic slope, in feet per foot: 0.001525

0 0		: Unit	0	Cost
Item :	Quantity	: price	8	COST
CAPITAL COSTS				
Excavation, unclassified Backfill, compacted Backfill, consolidated Pipe, steel, mortar-lined, concrete coated, 36-inch I.D.		\$ 1.20 3.00 0.75	\$ 410,900 76,200 102,900	
10-gage 8-gage 3/16-inch 1/4-inch Manhole Manhole and air valve Manhole and blowoff Vent structure Right of way	114,300 lin.ft. 5,200 lin.ft. 3,300 lin.ft. 4,200 lin.ft. 7 each 43 each 26 each 20 each	16.50 17.00 18.30 21.25 325.00 490.00 570.00 630.00 lump sum	1,886,000 88,400 60,400 89,200 2,300 21,100 14,800 12,600 100,000	
Subtotal				\$2,864,800
Administration and engineer Contingencies, 15% Interest during construction construction	•	alf of 1-	year	286,500 429,700 <u>71,600</u>
TOTAL				\$3,652,600
ANNUAL COSTS		-		
Interest, 3.5% Amortization, 40-year sink Operation and maintenance	cing fund at 3.5%			\$ 127,800 43,200 3,700
TOTAL				\$ 174,700

ESTIMATED COST OF PAMO "B" DAM AND RESERVOIR WITH STORAGE CAPACITY OF 163,400 ACRE-FEET

(Based on prices prevailing in 1958)

Elevation of crest of dam: 1,100 feet, U.S.G.S. datum Elevation of crest of spillway: 1,079 feet

Elevation of crest of spillway: 1,079 feet Height of dam to spillway crest, above stream bed: 229 feet Capacity of reservoir to crest of spillway: 163,400 acre-feet Capacity of spillway with 5-foot freeboard: 75,000 second-feet

	0		: Unit	0	
It em.	: Quanti	ty	: price	9	Cost
CAPITAL COSTS					
Dam					
Exploration			lump sum	\$ 50 ₉ 000	
Diversion of stream ar					
dewatering of founda	3.==				
tion			lump sum	50,000	
Stripping topsoil	279,500 d	xx.yd.	\$ 0.35	97,800	
Excavation for embank-	ь				
ment					
Foundation	445,300 c	w.yd.	0.70	311,700	
Impervious from			- /-		
borrow pits	2,223,200	w.yd.	0.60	1,333,900	
Random from stream					
bed and borrow			- 4		
pits	3,855,100 0	u.yd.	0.65	2,505,800	
Embankment					
Impervious	1,933,200 0		0.15	290,000	
Random	3,292,500 0		0.12	395,100	
Random salvage	742,400 c		0.20	148,500	
Rock riprap	105,200		2.80	294,600	
Drilling grout holes	19,900 1		4.00	79,600	
Pressure grouting	13,300 0		3.00	39,900	Au mad coo
Gravel drains	59,800 c	ou.yd.	3.00	179,400	\$5,776,300
0. 29 9 8					
Spiliway					
Excavation	- FILL FOO -	3	7 50	03.4 000	
unclassified Backfill	544,500		1.50	816,800	
	1.,000		1.50	1,500	
Rock riprap	ALU C	u.yd.	2.80	1,100	
Concrete					
Weir, cutoff, and	0 7700	3	15 00	70r 600	
flip bucket	2,790		45.00	125,600	
Floor	3,000 0		40.00	120,000	
Walls		zu.yd.	50.00	35,000	
Reinforcing steel	496,700 1		0.15	74,500	
Drilling grout holes	3,600]		4.00	14,400	7 704 700
Pressure grouting	2,400 0	u.it.	3.00	7,200	1,196,100

ESTIMATED COST OF PAMO "B" DAM AND RESERVOIR WITH STORAGE CAPACITY OF 163,400 ACRE-FEET (continued)

	:	A 2 4		Unit	:		0
Item	: Quan	LILY		price			Cost
CAPITAL COSTS							
Outlet Works							
Excavation							
Inlet and outlet			43		ш		
structures		cu.yd.			\$	5,600	
Conduit		cu.yd.		1.50		13,800	
Backfill	5,900	cu.yd.		4.50		26,600	
Concrete Pipe encasement	2 1.20	cu.yd.		50.00		121,000	
Intake tower		cu.yd.		60.00		89,400	
Reinforcing steel	508,300			0.15		76,200	
Miscellaneous	7003700			-0-2		,0,200	
metalwork	15,000	lbs.		0.45		6,800	
Steel pipe, 30-inch	- 4					•	
dia., intake tower			10	mp sum		9,500	
Butterfly valves,							
30-inch dia., intake							
tower		each	4,0	00.00		20,000	
Steel pipe, 54-inch	211,000	713		0.00		100 000	
dia.	344,000	lbs.		0.30		103,200	
High pressure slide gate			7.	mr enm		27,500	
Gate valve, 54-inch			Tr	mp sum		27,500	
dia.	1	each	7.5	00.00		7,500	
Needle valve, 36-inch	_	04011	132			1,500	
dia.	1	each	17.0	00.00		17,000	
Pressure regulators		each		.00.00		8,400	
Venturi meter				mp sum		4,100	
Control house			lu	mp sum		5,000	\$ 541,600
Reservoir							
Clearing reservoir land	ds 2,100	ac.		35.00		73,500	
Road relocation						-() 000	
(truck trails)			Tu	mp sum		264,000	
Access road, Pamo grade to dam	e		٦.,	mn alim		150 000	
Caretaker's house and	chon			mp sum		150,000 20,000	507,500
	anop		10	mp som		_20,000	
Subtotal							\$ 8,021,500
Administration and engine	eering, l	0%					\$ 802,200
Contingencies, 15%	O,						1,203,200
Real estate*							375,000
Subtotal							\$10,407,000
							\$10,401,900
Interest during construct	tion, 4%	for one	-hal	f of 2	• 5-3	rear	700 300
construction period							520,100
TOTAL							\$10,922,000
							,,,,,,

ESTIMATED COST OF PAMO "B" DAM AND RESERVOIR WITH STORAGE CAPACITY OF 163,400 ACRE-FEET (continued)

Item	° °	Quantity	00	Unit price	8	Cost
ANNUAL COSTS						
Interest, 3.5% Amortization, 40-ye Operation and maint		g fund at 3.	, 5%			\$ 382,300 129,200 16,300
TOTAL						527,800

^{*} Detail costs of land, improvements, and acquisition are presented in Table K-6.

ESTIMATED COST OF PAMO-MIRAMAR CONDUIT TO ACCOMPANY RESERVOIR OF 163,400 ACRE-FEET CAPACITY

(Based on prices prevailing in 1958)

Length of conduit, in miles: 24
Inside diameter of pipe, in inches: 38
Design capacity of pipe, in
second-feet: 34
Cross-sectional area of pipe, in

square feet: 7.88

Average velocity, in feet per second: 4.33 Manning's value of "n": 0.0115 Hydraulic radius, in feet: 0.792 Hydraulic slope, in feet per foot: 0.001525

Item		Unit :	Cost	
CAPITAL COSTS		,		
Excavation, unclassified Backfill, compacted Backfill, consolidated Pipe, steel, mortar-lined, concrete coated, 38-inch	353,800 cu.yd. 27,900 cu.yd. 142,200 cu.yd.	\$ 1.20 3.00 0.75	\$ 424,600 83,700 106,700	
I.D. 10-gage 8-gage 3/16-inch 1/4-inch Manhole Manhole and air valve Manhole and blowoff Vent structure Right of way	111,600 lin.ft. 7,400 lin.ft. 3,100 lin.ft. 4,900 lin.ft. 7 each 43 each 26 each 20 each	16.95 17.85 19.25 22.55 350.00 510.00 590.00 650.00 lump sum	1,891,600 132,100 59,700 110,500 2,400 21,900 15,300 13,000	
Subtotal			\$2,961,	500
Administration and engineer Contingencies, 15% Interest during construction construction		lf of l-year		
TOTAL			\$3,775,	
ANNUAL COSTS				
Interest, 3.5% Amortization, 40-year sinki Operation and maintenance	ng fund at 3.5%		\$ 132, 44, 3,	
TOTAL			\$ 180,	700

ESTIMATED COST OF LAND AND IMPROVEMENTS FOR THREE SIZES OF DAM AND RESERVOIR AT THE SAN PASQUAL SITE ON SAN DIEGUITO RIVER IN SAN DIEGUITO RIVER WATERSHED

		at own go on one	i+3r
•	Gross 1	reservoir storage capac in acre-feet	:10 y ,
	100,000	220,000	335,000
GENERAL FEATURES			`
Water surface elevation			
for design flood, in feet, U.S.G.S. datum	428	460	485
Land necessary for project, in acres			_
Owned by City of San Diego	3,060	3,810	3,980
Privately-owned	1,310	2,090	2,590
Totals	4,370	5,900	6,570
Number of privately-	50	70	75
owned parcels	<i>></i>	10	12
CAPITAL COSTS			
Property owned by City of San Diego Land \$1 Improvements	1,247,000 351,000 \$1,598,000	\$1,382,000 351,000 \$1,733,000	\$1,537,000
Privately-owned	and the state of t		
property Iand	587,000	921,000	1,024,000
Improvements	475,000	1,285,000	1,285,000
Acquisition	50,000 1,112,000	70,000 2,276,000	
Subtotals	\$2,710,000	\$4,009,000	\$4,272,000
Contingencies, 15%	407,000	601,000	641,000
PROJECT TOTALS	\$3,117,000*	\$4,610,000	\$4,913,000
ADDITIONAL COST TO CITY	OF CAN DIECO		
	OF BAN DIEGO		
Privately-owned property	\$1,112,000	\$2,276,000	\$2,384,000
Contingencies, 15%	167,000	341,000	
TOTALS	\$1,279,000	\$2,617,000	\$2,741,000

^{*} Value should be increased by the amount of \$1,133,000 when San Pasqual ground water basin and San Pasqual surface reservoir are operated conjunctively.

ESTIMATED COSTS OF WELLS, PUMPING PLANTS, AND CONVEYANCE FACILITIES FOR GROUND WATER DEVELOPMENT WITHIN SAN PASQUAL RESERVOIR AREA

Maximum ground water storage capacity utilized: 37,000 acre-feet Average depth to ground water at maximum basin depletion: 80 feet

Item	Quant	tity	Unit : price :	Cos	t
CAPITAL COSTS					
Wells Drill, case, perforate, gravel pack and develop 13 new wells, 16-in. diameter	2,360	lin.ft.	\$ 33.00	\$ 77,900	\$ 77,900
Pumps Deep well submersible, furnish and install 30 HP 50 HP	_	each each	5,400.00 6,100.00	32,400 42,700	75,100
Pipe Steel, concrete coated, mortan lined, furnish and install 10-inch I.D., 12 gage 12-inch I.D., 12 gage 16-inch I.D., 12 gage 18-inch I.D., 12 gage 20-inch I.D., 12 gage 22-inch I.D., 12 gage 30-inch I.D., 10 gage	6,300 7,000 3,300 1,900 2,500 7,100	lin.ft. lin.ft. lin.ft. lin.ft. lin.ft. lin.ft. lin.ft.	3.20 3.90 6.10 6.80 7.50 8.50 12.20	20,200 27,300 20,100 12,900 18,800 60,400 146,400	306,100
Valves			lump sum	28,000	
Manholes and Vents			lump sum	27,600	55,600
Earthwork Excavation Backfill, compacted Backfill, consolidated	4,100	cu.yds. cu.yds. cu.yds.	0.45 3.00 0.75	15,900 12,300 22,600	50,800

ESTIMATED COSTS OF WELLS, PUMPING PLANTS, AND CONVEYANCE FACILITIES FOR GROUND WATER DEVELOPMENT WITHIN SAN PASQUAL RESERVOIR AREA (continued)

Item	Quantity	0	Unit : price :	Cos	t	
CAPITAL COSTS						
Power Transmission Lines Transformers	5.3 miles		4,000.00	\$21,200		
For 30 HP pumps For 50 HP pumps	6 each 7 each		1,500.00	9,000 14,000		
Service Road	2 miles		7,150.00	14,300	\$ 58,500	
Subtotal					\$624,000	
Administration and Engineering, 10	%				62,400	
Contingencies, 15%					93,600	
Subtotal					\$780,000	
Interest during construction, 4% f of 1-year construction period	or one-half				15,600	
TOTAL					\$795,600	
ANNUAL COSTS						
Interest, 3.5%					\$ 27,800	
Amortization, 40-year sinking fund at 3.5%						
Operation and maintenance					800	
Electric energy for pumping					3,000	
TOTAL					\$ 41,000	

ESTIMATED COST OF SAN PASQUAL DAM AND RESERVOIR WITH STORAGE CAPACITY OF 100,000 ACRE-FEET

(Based on prices prevailing in 1958)

Elevation of crest of dam: 433 feet,

U.S.G.S. datum

Elevation of crest of spillway: 413 feet Height of dam to spillway crest, above

stream bed: 80 feet

Capacity of reservoir to crest of spillway: 100,000 acre-feet Capacity of spillway with 5-foot freeboard: 123,300 second-feet

Unit price Cost Item Quantity CAPITAL COSTS Dam 45,000 Exploration lump sum \$ Diversion of stream and dewatering of foundation lump sum 100,000 154,400 441,000 cu.yd. \$ 0.35 Stripping topsoil Excavation for embankment 544,600 778,000 cu.yd. 0.70 981,000 cu.yd. 0.35 343,400 Impervious from borrow pits Embankment 128,000 853,000 cu.yd. 0.15 Impervious 400,000 cu.yd. 0.20 80,000 Impervious, salvage Random, salvage 1,247,300 cu.yd. 0.20 249,500 121,400 50;600 cu.yd. 2.40 Rock riprap 4.00 69,100 17,280 lin.ft. Drilling grout holes 45,800 15,260 cu.ft. 3.00 Pressure grouting Gravel drains 118,700 cu.yd. 3.00 356,100 \$ 2,237,300 Spillway 1,998,800 1.00 Excavation, unclassified 1,998,800 cu.yd. 18,400 12,250 cu.yd. 1.50 Backfill 2.40 5,470 cu.yd. 13,100 Rock riprap Concrete 45.00 122,000 Weir and cutoff 2,710 cu.yd. 12,900 cu.yd. 40.00 516,000 Floor 86,500 1,730 cu.yd. 50.00 Walls 216,900 1,445,700 lbs. 0.15 Reinforcing steel 28,800 Drilling grout holes 7,200 lin.ft. 4.00 14,400 3,014,900 Pressure grouting 4,800 cu.ft. 3.00 Outlet Works Excavation Inlet and outlet structures 1,440 cu.yd. 2.00 2,900 Conduit 3,640 cu.yd. 1.50 5,500 Backfill 4.50 10,600 2,350 cu.yd.

ESTIMATED COST OF SAN PASQUAL DAM AND RESERVOIR WITH STORAGE CAPACITY OF 100,000 ACRE-FEET (continued)

		2 II			
Têom	2 Quantity	: Unit : price	00 00	Co	st
Item	a Quarror by	° price	٥	00	5 0
CAPITAL COSTS					
Outlet Works (continued)					
Concrete					
Pipe encasement	960 cu.yd.		\$	48,000	
Intake tower	630 cu.yd.			37,800	
Reinforcing steel	207,200 lbs.	0.15		31,100	
Miscellaneous metalwork	16,500 lbs.	0.45		7,400	
Steel pipe, 30-inch dia.,	20 100 71	0.00		0 300	
intake tower	10,400 lbs.	0.30		3,100	
Butterfly valves, 30-inch	2	1 200 00		30 600	
dia., intake	3 each	4,200.00		12,600	
Steel pipe, 48-inch dia.	111,400 lbs.	0.30		33,400	
High pressure slide gate	l each	lump sum		15,000	
Gate valve, 42-inch dia.	l each	lump sum		6 _s 200	
Venturi meter	l each l each	lump sum		4,100	\$ 222,700
Control house	1 each	lump sum		5 ₉ 000	\$ 222,700
Reservoir					
Clearing reservoir lands	2,925 ac.	35.00		102,400	
Relocation of utilities		lump sum		284,000	
Road relocation ^a		lump sum	1,	000,000	
Access road		lump sum		1.0,000	2 12 () 00
Caretaker's house and shop		lump sum		20,000	1,416,400
Subtotal					\$ 6,891,300
Administration and engineering,	109				689,100
Contingencies, 15%	1.0%				1,033,700
Real estateb					3,117,000°
near estate					251115000
Subtotal					\$11,731,100
Interest during construction, 47					
one-half of l-year construction	on period				234,600
TOTAL					\$11,965,700
ANNUAL COSTS					
Interest, 3.5%					\$ 418,800
Amortization, 40-year sinking fu	and at 3.5%				141,600
Operation and maintenance					12,500
TOTAL					\$ 572,000 ^d
IOINI					# 712 good

a. Based on estimate contained in State Division of Highways interdepartmental communication, dated March 7, 1956, presented hereinafter in this appendix.

b. Detailed costs of land, improvements, and acquisitions are presented in Table K-13.

c. Cost of real estate equals \$4,550,000 when San Pasqual ground water basin and San Pasqual surface reservoir are operated conjunctively.

d. Value should be increased by the amount of \$67,100 when San Pasqual ground water basin and San Pasqual surface reservoir are operated conjunctively.

ESTIMATED COST OF SAN PASQUAL-MIRAMAR CONDUIT AND SAN PASQUAL
RESERVOIR-LAKE HODGES CANAL TO ACCOMPANY RESERVOIR OF 100,000 ACRE-FEET CAPACITY
AND GROUND WATER STORAGE DEPLETION OF 37,000 ACRE-FEET

(Based on prices prevailing in 1958)

Pipe Line from San Pasqual to Pumping Plant

Length of conduit, in miles: 0.8
Inside diameter of pipe, in inches: 36

Design capacity of pipe, in

second-feet: 29.5

Cross-sectional area of pipe, in

square feet: 7.07

Pipe Line from Pumping Plant to Miramar

Length of conduit, in miles: 11.9
Inside diameter of pipe, in inches: 22

Design capacity of pipe, in

second-feet: 7.9

Cross-sectional area of pipe, in

square feet: 2.64

Average velocity, in feet per second: 4.17 Manning's value of "n": 0.0115 Hydraulic radius, in feet: 0.750 Hydraulic slope, in feet per foot: 0.001533

Average velocity, in feet

per second: 2.99

Manning's value of "n": 0.0115

Hydraulic radius, in feet: 0.458

Hydraulic slope, in feet

per foot: 0.001525

Canal from San Pasqual Pumping Plant to Lake Hodges

Length of canal, in miles: 3.4

Bottom width, in feet: 3.0

Depth of flow, in feet: 1.65

Design capacity of canal, in

second-feet: 22.0

Cross-sectional area of canal, in

square feet: 7.67

Average velocity, in feet per second: 2.9 Manning's value of "n": 0.015

Hydraulic radius, in feet: 1.0

Hydraulic slope, in feet per foot: 0.00083

addate teet. 1.01

Item	: Quantit	у :	Unit price	3	Cost
CAPITAL COSTS					
Pipe Line Excavation, unclassified Backfill, compacted Backfill, consolidated Manholes Manhole and air valve Manhole and blowoff Vent structure Pipe, steel, mortar-lined concrete-coated From San Pasqual Dam to pumping plant	110,500 cu. 7,100 cu. 60,900 cu. 5 eac 11 eac 15 eac	yd. yd. h h	3.00 3.00 0.75 200.00 300.00 400.00 450.00		\$ 133,000 21,300 45,600 1,000 3,300 6,000 2,300
36-inch I.D. 8-gage	4,200 ft.		17.00		71,400

ESTIMATED COST OF SAN PASQUAL-MIRAMAR CONDUIT AND SAN PASQUAL
RESERVOIR-LAKE HODGES CANAL TO ACCOMPANY RESERVOIR OF 100,000 ACRE-FEET CAPACITY
AND GROUND WATER STORAGE DEPLETION OF 37,000 ACRE-FEET
(continued)

	0 0	: Unit	e •	
Item	: Quantity	: price	: Cos	t
CAPITAL COSTS				
From pumping plant to Miramar Reservoir				
22-inch I.D.				
12-gage	56,400 ft.	\$ 9.45	\$ 553,000	
10-gage	3,500 ft.	10.60	37,100	
8-gage	2,600 ft.	11.10	28,900 \$	902,900
San Pasqual Reservoir to				
Lake Hodges Canal				
Excavation	51,100 cu.yd.	0.45	23,000	
Embankment	10,700 cu.yd.	0.45	4,800	
Trimming	21,000 sq.yd.	0 , 50	10,500	
Concrete lining	3,130 cu.yd.	28.00	87,600	
Siphons and culverts	e e	lump sum	11,500	
Fencing, 4-strand barbed wire	13.8 miles	2,700.00	37,300	174,700
Pumping Plant, 600 H.P.				
Cost of structure, pumps,				
motors, electric equip-				
ment and miscellaneous				
equipment, furnish and install		lump sum	67,600	67,600
Right of way		lump sum	55,000	55,000
Subtotal			ψ.	1,200,200
baooogar			ψ.	1,200,200
Administration and engineering,	10%			120,000
Contingencies, 15%				180,000
Subtotal			\$:	1,500,200
Interest during construction, 4%	for one-half of	l-vear		
construction period		. – , –		30,000
TOTAL			\$3	1,530,200
ANNUAL COSTS				
Interest, 3.5%			\$	53,600
Amortization, 4C-year sinking fu	nd at 3.5%		*	18,100
Operation and maintenance	<u> </u>			20,500
Electric energy for pumping				9,400
TOTAL			\$	101,600

TABLE K-17

ESTIMATED COST OF SAN PASQUAL DAM AND RESERVOIR WITH STORAGE CAPACITY OF 220,000 ACRE-FEET

(Based on prices prevailing in 1958)

Elevation of crest of dam: 465 feet,

U.S.G.S. datum

Elevation of crest of spillway: 446 feet

Height of dam to spillway crest, above

stream bed: 113 feet

Capacity of reservoir to crest of spillway: 220,000 acre-feet Capacity of spillway with 5-foot

freeboard: 115,600 second-feet

Item	Quantit	y	Unit price	:	C	ost
CAPITAL COSTS						
Main Dam						
Exploration			lump sum	\$	60,000	
Diversion of stream and dewatering of foundation			lump sum		100,000	
Stripping topsoil Excavation for embankment	649,000 c	u.yd.	\$ 0.35		227,200	
Foundation	976,000 c		0.70		683,200	
Impervious from borrow pits Random from stream bed	1,646,800 e 1,417,400 c		0.40		658,700 567,000	
Embankment						
Impervious Impervious, salvage	1,432,000 c .249,000 c		0.15		214,800 49,800	
Random	1,232,500 c 1,010,000 c	-	0.12		147,900	
Random, salvage Rock riprap	68,000 c	u.yd.	2.40		163,200	
Drilling grout holes Pressure grouting	18,800 1 12,500 c				75,200 37,500	
Gravel drains	178,000 c		3.00		534,000	\$3,720,500
Auxiliary Dam.						
Stripping topsoil and excava- tion for foundation	62,000 c	n vd .	0.35		21,700	
Embankment	·					
Impervious, salvage Random, salvage	80,000 c 81,800 c		0.20		16,000 16,400	
Gravel drain, salvage	8,700 c		3.00 2.40		26,100 24,500	
Rock riprap Drilling grout holes	13,800 1	in.ft.	4.00		55,200	
Pressure grouting Gravel drains	9,200 c		3.00 3.00		27,600 (26,100	213,600

ESTIMATED COST OF SAN PASQUAL DAM AND RESERVOIR WITH STORAGE CAPACITY OF 220,000 ACRE-FEET (continued)

	M. Maria Carlo Cher Manajara, yanya a		77		
Item	: Quant	ity	: Unit : price	•	Cost
CAPITAL COSTS					
Spillway					
Excavation, unclassified	1,393,000	cu.yd.	\$ 1.00	\$1,393,000	
Backfill		cu.yd.		11,400	
Rock riprap Concrete	4,670	cu.yd	2.40	11,200	
Weir and cutoff	2,800	cu.yd.	45.00	126,000	
Floor		cu.yd.		931,600	
Walls	4,410	cu.yd.		220,500	
Reinforcing steel	2,536,500		0.15	380,500	
Drilling grout holes Pressure grouting		lin.ft cu.ft.		28,800	do 337 1.00
11000mc Brouotng	4,000	Cuore	3.00	14,400	\$3,117,400
Outlet Works					
Excavation					
Inlet and outlet structures Conduit		cu.yd.		3,800	
Backfill		cu.yd.		9,600 18,500	
Concrete	49200	cueyue	40,00	10,500	
Pipe encasement	1,650	cu.yd.	50.00	82,500	
Intake tower		cu.yd.		51,000	
Reinforcing steel Miscellaneous metalwork	325,000		0.15	48,800	
Steel pipe, 36-inch dia.,	32,000	LDS.	0.45	14,400	
intake tower	15,500	lbs.	0.30	4,700	
Butterfly valves, 36-inch				.,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
dia., intake tower		each	5,600.00	22,400	
Steel pipe, 66-inch dia. High pressure slide gate	275,700		0.30	82,700	
Gate valve, 66-inch dia.		each each	lump sum	32,000 10,500	
Venturi meter		each	lump sum	5,000	
Control house		each	lump sum	5,000	390,900
Reservoir					
Clearing reservoir lands	4,300	80	25.00	7.50 500	
Relocation of utilities	4,300	ac.	35.00 lump sum	150,500 280,000	
Road relocation a			lump sum	1,000,000	
Access road			lump sum	10,000	
Caretaker's house and shop			lump sum	20,000	1,460,500
Subtotal					\$8 000 000
					\$8,902,900

ESTIMATED COST OF SAN PASQUAL DAM AND RESERVOIR WITH STORAGE CAPACITY OF 220,000 ACRE-FEET (continued)

		lania erre relativos de la contra de constituido de la constituido de la constituido de la constituido de la c			
	0		: Unit	:	
Item	0	Quantity	: price	O O O O O O O O O O O O O O O O O O O	Cost
CAPITAL COSTS					
Administration and engine Contingencies, 15% Real estate	ering, l	0%			\$ 890,300 1,335,400 4,610,000
Subtotal					\$15,738,600
Interest during construct one-half of 2-year cons					629,500
TOTAL					\$16,368,100
ANNUAL COSTS					,
Interest, 3.5% Amortization, 40-year sin Operation and maintenance		d at 3.5%			\$ 572,900 193,600 19,700
TOTAL					\$ 786,200

a. Based on estimate contained cin State Division of Highways Linter-departmental communication, dated March 7, 1956, presented hereinafter in this appendix.

b. Detail costs of land, improvements, and acquisition are presented in Table K-13.

ESTIMATED COST OF SAN PASQUAL*MIRAMAR CONDUIT AND SAN PASQUAL
RESERVOIR LAKE HODGES CANAL TO ACCOMPANY RESERVOIR OF 220,000 ACRE-FEET CAPACITY
AND GROUND WATER STORAGE DEPLETION OF 37,000 ACRE-FEET

(Based on prices prevailing in 1958)

Pipe Line from San Pasqual to Pumping Plant

Length of conduit, in miles: 0.8
Inside diameter of pipe, in inches: 40
Design capacity of pipe, in
second-feet: 40.0

Cross-sectional area of pipe, in square feet: 8.73

Pipe Line from Pumping Plant to Miramar

Length of conduit, in miles: 11.9
Inside diameter of pipe, in inches: 30
Design capacity of pipe, in
second-feet: 18.1

Cross-sectional area of pipe, in square feet: 4.91

Average velocity, in feet per second: 4.6 Manning's value of "n": 0.0115 Hydraulic radius, in feet: 0.832 Hydraulic slope, in feet per foot: 0.001618

Average velocity, in feet per second: 3.69 Manning's value of "n": 0.0115 Hydraulic radius, in feet: 0.625 Hydraulic slope, in feet per foot: 0.001525

Canal from San Pasqual Pumping Plant to Lake Hodges

Length of canal, in miles: 3.4
Bottom width, in feet: 3.0
Depth of flow, in feet: 1.65
Design capacity of canal, in
second-feet: 22.0

Cross-sectional area of canal, in

square feet: 7.67

Average velocity, in feet
per second: 2.9
Manning's value of "n": 0.015
Hydraulic radius, in feet: 1.0
Hydraulic slope, in feet
per feet: 0.00083

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	The commence of the control of the control				-	
Item	° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° ° °	Quantity		Unit price		Cost
CAPITAL COSTS						
Pipe Line Excavation, unclassified Backfill, compacted Backfill, consolidated Manholes Manhole and air valve Manhole and blowoff Vent structure Pipe, steel, mortar-lined concrete coated From San Fasqual Dam to pumping plant 40-inch I.D.		127,900 cu.yd. 11,200 cu.yd. 61,000 cu.yd. 5 each 11 each 15 each 5 each	2 3 4	1. 20 3 00 0 75 50 00 50 00		\$ 153,500 33,600 46,000 1,300 3,500 6,800 2,500
8 gage		4,200 ft.		18.80		79,000

ESTIMATED COST OF SAN PASQUAL-MIRAMAR CONDUIT AND SAN PASQUAL RESERVOIR-LAKE HODGES CANAL TO ACCOMPANY RESERVOIR OF 220,000 ACRE-FEET CAPACITY AND GROUND WATER STORAGE DEPLETION OF 37,000 ACRE-FEET (continued)

The section is the second contract of the sec		: Unit :	mer for ann anniquips spirits are arrested community consistent	response representation and the endocated distribution with the contra
Item	: Quantity	: Price :	Cos	t
CAPITAL COSTS				
From pumping plant to Miramar Reservoir 30-inch I.D. 10-gage	56,500 ft.	\$ 13.20	\$ 745,800	
8-gage 3/16-inch 1/4-inch	2,500 ft. 1,500 ft. 1,600 ft.	13.90 14.95 17.60	140,300 22,400 28,200	\$1,163,300
San Pasqual Reservoir to Lake Hodges Canal Excavation Embankment Trimming Concrete lining Siphons and culverts	51,100 cu.yd. 10,700 cu.yd. 21,000 sq.yd. 3,130 cu.yd.	0.45 0.45 0.50 28.00 lump sum	23,000 4,800 10,500 87,600 11,500	174,700
Fencing, 4-strand barbed wire Pumping Plant, 1,250 H.P. Cost of structure, pumps, motors, electric equip- ment and miscellaneous	13.0 miles	2,700.00	37,300	
equipment, furnish and install		lump sum	134,000	134,000
Right of way		lump sum	55,000	55,000
Subtotal				\$1,527,000
Administration and engineering, 1 Contingencies, 15%	Oç'			152,700 229,000
Subtotal				\$1,908,700
Interest during construction, 4% construction period	for one-half of	l-year		38,200
TOTAL				\$1,546,500
ANNUAL COSTS				
Interest, 3.5% Amortization, 40-year sinking fun Operating and maintenance Electric energy for pumping	d at 3.5%			\$ 68,100 23,000 23,700 27,800
TOTAL				\$ 142,600

ESTIMATED COST OF SAN PASQUAL DAM AND RESERVOIR WITH STORAGE CAPACITY OF 335,000 ACRE-FEET

(Based on prices prevailing in 1958)

Elevation of crest of dam: 490 feet, U.S.G.S. datum Elevation of crest of spillway: 470 feet Height of dam to spillway crest, above stream bed: 137 feet Capacity of reservoir to crest of spillway: 335,000 acre-feet Capacity of spillway with 6-foot freeboard: 111,800 second-feet

	9		: Unit	0	
	: Quanti		: Unit : price	: Co	ost
CAPITAL COSTS					
Main Dam					
Exploration			lump sum	\$ 70,000	
Diversion of stream and				4	
dewatering of foundation			lump sum	100,000	
Stripping topsoil	741,000	cu.yd.		259,400	
Excavation for embankment			4	-,,,	
Foundation	1,207,400	cu.yd.	0.70	845,200	
Impervious from borrow pits				1,197,000	
Random from stream bed					
and borrow pits	2,642,600	cu.yd.	0.45	1,189,200	
Embankment	-,,				
Impervious	2,309,700	cu.vd.	0.15	346, 500	
Impervious, salvage	131,000			26,200	
Random	2,298,000			275,800	
Random, salvage	648,300	cu.vd.	0.20	129,700	
Rock riprap		cu.yd.		223,400	
Drilling grout holes		lin.ft.		82,000	
Pressure grouting		cu.ft.		41,100	
Gravel drains	242,600			727,800	\$ 5,513,3
		0	3.1	1-17	Ψ 2, 2-3,
Auxiliary Dams					
Stripping topsoil and	07.0 500		2 25	76 000	
excavation for foundation	219,700	cu.ya.	0.35	76,900	
Excavation for embankment	276 000	1	2 1.5	(00	
Impervious from borrow pits				97,600	
Random from stream bed	345,900	cu.ya.	0.45	155,700	
Embankment	a Cl. 1:00	-3	2.25	=1, 500	
Impervious	364,400			54,700	
Impervious, salvage	175,800			35,200	
Random	125,000			15,000	
Rock riprap		cu.yd.		89,300	
Drilling grout holes		lin.ft.		125,600	
Pressure grouting		cu.ft.		63,000	Com
Gravel drains	61,500	cu.yd.	. 3.00	184,500	897,

ESTIMATED COST OF SAN PASQUAL DAM AND RESERVOIR WITH STORAGE CAPACITY OF 335,000 ACRE-FEET (continued)

Item	: Quantity	:	Unit price	:	Co	st.
Trem	· Anamorol		02 400			30
CAPITAL COSTS						
Spillway						
Excavation, unclassified	657,800 cu		\$ 1.50	\$	986,700	
Backfill	16,700 cu		1.50		25,100	
Rock riprap	5,340 cu	ı.yd.	2.40		12,800	
Concrete	- (1. = 00		3.03. 3.00	
Weir and cutoff	2,690 cu		45.00		121,100	
Floor	22,040 cu		40.00		881,600	
Walls	5,400 cu		50.00		270,000	
Reinforcing steel	2,601,300 lt		0.15 4.00		390,200 28,800	
Drilling grout holes	7,200 li				14,400	\$ 2,730,700
Pressure grouting	4,800 cu	tollo	3.00	dum	14,400	ψ 2, 130, 100
Outlet Works						
Excavation						
Inlet and outlet structures	2,200 cu	ı.vd.	2.00		4,400	
Conduit	12,100 cu	-	1.50		18,200	
Backfill	7,600 cu		4.50		34,200	
Concrete						
Pipe encasement	3,380 cu	ı.yd.	50.00		169,000	
Intake tower	1,050 cu	ı.yd.	60.00		63,000	
Reinforcing steel	577,000 11		0.15		86,600	
Miscellaneous metalwork	45,000 lt	98.	0.45		20,300	
Steel pipe, 42-inch dia.,					0	
intake tower	19,500 11		0.30		5,800	
Butterfly valves, 42-inch dia		-	,200.00		36,000	
Steel pipes, 60-inch dia. (2)			0,30		167,000	
High pressure slide gates	2 es		lump sum		57,000	
Gate valves, 60-inch dial	2 ea		,000.00		18,000	
Venturi meter	l ea		lump sum		6,000	690,500
Control house	l ea	acn	lump sum	_	5,000	090,500
Reservoir						
Reservoir Clearing reservoir lands	5,000 ad	3.	35.00		175,000	
Relocation of utilities),000 at		lump sum		280,000	
Road relocation ^a			lump sum	1	.,000,000	
Access road			lump sum		10,000	
Caretaker's house and shop			lump sum		20,000	1,485,000
				_		
Subtotal						\$11,317,000

ESTIMATED COST OF SAN PASQUAL DAM AND RESERVOIR WITH STORAGE CAPACITY OF 335,000 ACRE-FEET (continued)

Item	: Quantity	: Unit : : price :	Cost
CAPITAL COSTS			
Administration and engineer Contingencies, 15% Real estateb	eing, 10%		\$ 1,131,700 1,697,600 4,913,000
Subtotal			\$19,059,300
Interest during construction one-half of 2.5-year cons			953,000
TOTAL			\$20,012,300
ANNUAL COSTS			
Interest, 3.5% Amortization, 40-year sinki Operation and maintenance	ng fund at 3.5%		\$ 700,400 236,700 26,600
TOTAL			\$ 963,700

a. Based on estimate contained in State Division of Highways inter-departmental communication, dated March 7, 1956, presented hereinafter in this appendix. b. Detail costs of land, improvements, and acquisition are presented in Table K-13.

TABLE K.20

ESTIMATED COST OF SAN PASQUAL-MIRAMAR CONDUIT AND SAN PASQUAL RESERVOIR - LAKE HODGES CANAL TO ACCOMPANY RESERVOIR OF 335,000 ACRE-FEET CAPACITY AND GROUND WATER STORAGE DEPLETION OF 37,000 ACRE-FEET

(Based on prices prevailing in 1958)

Pipe Line from San Pasqual to Pumping Plant

Length of conduit, in miles: 0.8

Inside diameter of pipe, in inches: 44

Design capacity of pipe, in

second-feet: 51.7

Cross-sectional area of pipe; in

square feet: 10.6

Pipe Line from Pumping Plant to Miramar

Length of conduit, in miles: 11.9

Inside diameter of pipe, in inches: 36

Design capacity of pipe, in

second-feet: 29.4

Cross-sectional area of pipe, in

square feet: 7.07

per second: 4.9 Maining's value of "n": 0.0115 Hydraulic radius, in feet: 0.918

Hydraulic slope, in feet

Average velocity, in feet

per foot: 0.001618

Average velocity, in feet per second: 4.16 Manning's value of "n": 0.0115 Hydraulic radius, in feet: 0.750

Hydraulic slope, in feet per foot: 0.001525

Canal from San Pasqual Pumping Plant to Lake Hodges

Length of canal, in miles: 3.4 Bottom width, in feet: 3.0

Depth of flow, in feet: 1.65

Design capacity of canal, in

second-feet: 22.0

Cross-sectional area of canal, in

square feet: 7.67

Average velocity, in feet per second: 2.9 Manning's value of "n": 0.015 Hydraulic radius, in feet: 1.0

Hydraulic slope, in feet per foot: 0.00083

Unit Item Quantity Price Cost CAPITAL COSTS Pipe Line Excavation, unclassified 145,200 cu.yd. \$ 1.20 \$ 174,200 Backfill, compacted 11,900 cu.yd 3.00 34,200 Backfill, consolidated 69,000 cu.yd. 51,700 0.75 Manholes 5 each 325.00 1,600 ll each Manhole and air valve 490.00 5,400 8,600 Manhole and blowoff 15 each 570.00 Vent structure 5 each 630.00 3,200 Pipe, steel, mortar-lined,

concrete coated From San Pasqual Dam to pumping plant 44-inch I.D.

8-gage

4,200 ft.

20.60

86,500

ESTIMATED COST OF SAN PASQUAL-MIRAMAR CONDUIT AND SAN PASQUAL
RESERVOIR LAKE HODGES CANAL TO ACCOMPANY RESERVOIR OF 335,000 ACRE-FEET CAPACITY
AND GROUND WATER STORAGE DEPLETION OF 37,000 ACRE-FEET
(continue)

Item	: Quantity	: Unit : : Price :	Сов	t
CAPITAL COSTS				
From pumping plant to				
Miramar Reservoir				
36-inch I.D.				
10-gage	54,500 ft.	\$ 16.50	\$ 899,300	
8-gage	2,400 ft.	17.00	40,800	
3/16-inch	2,100 ft.	18.30	38,400	
1/4=inch	3,500 ft.	21.25	74,400	\$1,418,300
San Pasqual Reservoir to				
Lake Hodges Canal				
Excavation	51,100 cu.yd.	0.45	23,000	
Embankment	10,700 cu.yd.	0.45	4,800	
Trimming	21,000 sq.yd.	0.50	10,500	
Concrete lining	3,130 cu.yd.	28.00	87,600	
Siphons and culverts	1,81 (04)	lump sum	11,500	
Fencing, 4-strand barbed wir	re 13.8 miles	2,700.00	37,300	174,700
Pumping Plant, 2,000 H.P. Cost of structure, pumps, motors, electric equipment and miscellaneous				
equipment, furnish and insta	11	lump sum	189,500	189,500
Right of way		lump sum	55,000	55,000
Subtotal				\$1,837,500
Administration and engineering Contingencies, 15%	;, 109			183,800 275,700
Subtotal				\$2,297,000
"nterest during construction,	4% for one-half of	f l-year		\ = 000
construction period				45,900
TOTAL				\$2,342,900
ANNUAL COSTS		\		
Interest. 3.5%				\$ 82,000
Amortization, 40-year sinking	fund at 3.5%			27,700
Operating and maintenance	10110 00 5.77			26,900
Electric energy for pumping				84,400
TOTAL				\$ 221,000

ESTIMATED COST OF LAND AND IMPROVEMENTS FOR THREE SIZES OF DAM AND RESERVOIR AT THE SUPER HODGES SITE ON SAN DIEGUITO RIVER IN SAN DIEGUITO RIVER WATERSHED

:	: Gross reservoir storage capacity,				
<u>:</u>	157,300	in acre-feet: 310,000	: 365,000		
GENERAL FEATURES					
Water surface elevation					
for design flood, in feet, U.S.G.S. datum	383	412	419		
Land necessary for					
project, in acres Owned by City of					
San Diego	6,680	7,740	8,100		
Privately-owned	200	1,520	1,990		
Totals	6,880	9,260	10,090		
Number of privately-					
owned parcels	157	220	250		
CAPITAL COSTS					
Property owned by City of San Diego Land \$2	2,284,000	\$3,188,000	\$3,475,000		
Improvements _	193,000 \$2,477,000	243,000 \$3,431,000	243,000 \$3,718,000		
Privately-owned property					
Land	468,000	700,000	763,000		
Improvements	841,000	1,083,000	1,283,000		
Acquisition _	157,000 1,466,000	220,000 2,003,000	250,000 2,296,000		
Subtotals	\$3,943,000	\$5,434,000	\$6,014,000		
Contingencies, 15%	591,000	815,000	902,000		
PROJECT TOTALS	\$4,534,000	\$6,249,000	\$6,916,000		
ADDITIONAL COST TO CITY	OF SAN DIEGO				
Privately-owned					
property	\$1,466,000	\$2,003,000			
Contingencies, 15%	220,000	300,000	344,000		
TOTALS	\$1,686,000	\$2,303,000	\$2,640,000		

ESTIMATED COST. OF RELOCATING HIGHWAYS FOR THREE SIZES OF DAM AND RESERVOIR AT THE SUPER HODGES SITE*

		Gros	ss reservoi	r storage cap	pacity.	
•			in ac	cre-feet		
8	157;	,300	; 310,	,000	: 365	5,000
Water surface ele- vation for design flood, in feet, U.S.G.S. datum		383		412		419
PROJECT COSTS						
U. S. Highway No. 39 Roadway and right of way, h lanes			\$3,645,000		\$3,886,000	3
Structures	1,843,000	\$4,590,000	7,288,000	\$10,933,000	7,288,000	\$11,174,00
State Sign Route No. Roadway and right of way, 2 lanes			473,000		851,000	
Structures	- openigende personner op namely personner in the state of the state o	67,000	50,000	523,000	60,000	911,00
Subtotals		\$4,657,000		\$11,456,000		\$12,085,00
Engineering and admi	n-	465,700		1,145,600		1,208,50
TOTALS		\$5,122,700		\$12,601,600		\$13,293,50
COSTS TO THE CITY OF	SAN DIEGO					
U. S. Highway No. 39	15					- 3
Roadway and right of way, 2 lanes	\$1,044,000		\$1,385,000		\$1,477,000	
Structures	1,198,000	\$2,242,000	4,737,000	\$ 6,122,000	4,737,000	\$ 6,214,00
State Sign Route No.	, 78	67,000		523,000		911,00
Subtotals		\$2,309,000		\$ 6,645,000		\$ 7,125,00
Engineering and admitration, 10%	.nis-	231,000		665,000		713,00
TOTALS		\$2,540,000		\$ 7,310,000		\$ 7,838,0

^{*} Based on data presented in inter-departmental communication from Division of Highways dated May 6, 1958, and data presented in Right of Way Contract between California State Division of Highways and the City of San Diego, dated May 27, 1954, which are included in another portion of this appendix.

ESTIMATED COST OF SUPER HODGES DAM AND RESERVOIR WITH STORAGE CAPACITY OF 157,300 ACRE-FEET

(Based on prices prevailing in 1958)

Elevation of crest of dam: 384 feet, U.S.G.S. datum Elevation of crest of spillway: 365 feet

Height of dam to spillway crest; above

stream bed: 165 feet

Capacity of reservoir to crest of spillway: 157,300 acre-feet Capacity of spillway with 1-foot freeboard: 115,000 second-feet

		: Unit	:	
Item	: Quantity	: price	.: C	ost
CAPITAL COSTS				
Dam (Including spillway)		•		
Exploration		lump sum	\$ 45,000	
Diversion of flow and dewatering of foundation		lump sum	25,000	
Excavation of foundation Concrete	108,500 cu.yd.	. ~	379,800	
Mass	296,900 cu.yd.	18.50	5,492,600	
Cooling Spillway training walls	296,900 cu.yd.	0.50	148,500	
and piers	1,410 cu.yd.		70,500	
Bridge and parapet walls	620 cu.yd.		37,200	
Reinforcing steel	189,000 lbs.	0.15	28,400	
Pressure grouting	8,900 cu.ft.	3.00	26,700	
Drilling grout holes and drains	16,200 lin.ft	4.00	64,800	\$ 6,318,500
Outlet Works				
Reinforced concrete	10 cu.yd.	50.00	500	
Trash rack steel	6,600 lbs.	0.15	1,000	
Steel pipe, 30-inch dia.	24,200 lbs.	0.30	7,300	
Gate valves, 30-inch dia.		3,500.00	17,500	
High pressure slide gate Needle valve and energy	3 each 1	.3,500.00	40,500	
dissipator	l each l	1,000.00	11,000	
Miscellaneous metalwork	207,800 lbs.	0.45	93,500	
Reinforcing steel	8,700 lbs.	0.15	1,300	(
Control house		lump sum	5,000	177,600
Reservoir				
Clearing reservoir lands	4,050 ac.	35.00	141,800	
Relocation of utilities		lump sum	337,500	1000-
Access roads		lump sum	7,500	486,800
Subtotal				\$ 6,982,900

ESTIMATED COST OF SUPER HODGES DAM AND RESERVOIR WITH STORAGE CAPACITY OF 157,300 ACRE-FEET (continued)

Item	: Quantity	: Unit : : price :	Cost
CAPITAL COSTS			
Administration and engineer Contingencies, 15% Real estate, land, and	ing, 10%		\$ 698,300 1,047,400
improvements ^a Relocation of state highway	b		4,534,000 5,122,700
Subtotal			\$18,385,300
Interest during construction one-half of 2-year construction			735,400
TOTAL			\$19,120,700
ANNUAL COSTS			
Interest, 3.5% Amortization, 40-year sinki Operation and maintenance	ng fund at 3.5%		\$ 669,200 226,200 15,900
TOTAL			\$ 911,300

a. Detail costs of land, improvements, and acquisition are presented in Table K-21.

b. Detail costs of state highway relocation are presented in Table K-22.

TABLE K-2L

ESTIMATED COST OF SUPER HODGES-MIRAMAR CONDUIT TO ACCOMPANY RESERVOIR OF 157,300 ACRE-FEET CAPACITY

(Based on prices prevailing in 1958)

Length of conduit, in miles: 10.4
Inside diameter of pipe, in inches: 20
Design capacity of pipe, in
second-feet: 6.3
Cross-sectional area of pipe, in
square feet: 2.18

Average velocity, in feet

per second: 2.9

Manning's value of "n": 0.0115

Hydraulic radius, in feet: 0.417

Hydraulic slope, in feet

per foot: 0.0016

: Unit.

	•	: OUTC	
Item	: Quantity	: Price	Cost
CAPITAL COSTS			
Pipe Line			
Excavation, unclassified	102,200 cu. yd.	\$ 1.20	
Backfill, compacted	5,500 cu. yd.	3.00	16,500
Backfill, consolidated	41,000 cu. yd.	0.75	30,800
Manholes	ll each	240.00	2,600
Manhole and air valve	18 each	300.00	5,400
Manhole and blowoff	19 each	330.00	6,300
Vent structure	2 each	360.00	700
Pipe, steel, mortar-lined, concrete coated, 20-inch I.D.			
12-gage	53,500 lin.ft.	7.50	401,300
10-gage	900 lin.ft.	8.35	7,500
8-gage	500 lin.ft.	8.90	4,500 \$ 598,200
	•		
Pumping Plants			
Cost of structure, pumps,			
motors, electric equip-			
ment and miscellaneous			
equipment, furnish and			
install	2		10.200
Plant No. 1 - 400 H.P.	•	sum	1,0,300
Plant No. 2 - 250 H.P.	Tumţ	sum	34,300 74,600
Right of way	lump	sum	50,000 50,000
Subtotal			\$ 722,800
			, , , , , , , , , , , , , , , , , , , ,

ESTIMATED COST OF SUPER HODGES-MIRAMAR CONDUIT TO ACCOMPANY RESERVOIR OF 157,300 ACRE-FEET CAPACITY (continued)

Item	٥٠ •	Quantity	Unit Price	:	Cost	
Administration and engineering, 10% Contingencies, 15%					\$	72,300 108,400
Subtotal					\$	903,500
Interest during construction, 4% for construction period	one-ha	alf of l-year			_	18,100
TOTAL					\$	921,600
ANNUAL COSTS Interest, 3.5% Amortization, 40-year sinking fund a Operation and maintenance Electric energy for pumping TOTAL	t 3.5%				\$	32,300 10,900 15,800 8,000

ESTIMATED COST OF SUPER HODGES DAM AND RESERVOIR WITH STORAGE CAPACITY OF 310,000 ACRE-FEET

(Based on prices prevailing in 1958)

Elevation of crest of dam: 413 feet, U.S.G.S. datum

Elevation of crest of spillway: 395 feet Height of dam to spillway crest, above

stream bed: 195 feet

Capacity of reservoir to crest of spillway: 310,000 acre-feet Capacity of spillway with 1-foot

freeboard: 102,000 second-feet

	: Unit :	
Item	: Quantity : price : Cost	
CAPITAL COSTS		
·		
Dam (Including spillway)		
Exploration	lump sum \$ 50,000	
Diversion of flow and dewatering of foundation	lump sum 25,000	
Excavation of foundation	126,600 cu.yd. \$ 3.50 443,100	
Concrete	100 000 000 000 000	
Mass	411,200 cu.yd. 18.50 7,607,200 411,200 cu.yd. 0.50 205,600	
Cooling Spillway training walls	411,200 cu.yd. 0.50 205,600	
and piers	1,330 cu.yd. 50.00 66,500	
Bridge and parapet walls	670 cu.yd. 60.00 40,200	
Reinforcing steel	200,400 lbs. 0.15 30,100 9,700 cu.ft. 3.00 29,100	
Pressure grouting Drilling grout holes and	9,700 cu.ft. 3.00 29,100	
drains	17,600 lin.ft. 4.00 70,400 \$ 8	3,567,200
Outlet Works Reinforced concrete	10 cu.yd. 50.00 500	
Trash rack steel	14,800 lbs. 0.15 2,200	
Steel pipe, 42-inch dia.	41,500 lbs. 0.30 12,500	
Gate valves, 42-inch dia.	6 each 5,100.00 30,600	
High pressure slide gates Needle valve and energy	150,000 lbs. 0.50 75,000	
dissipator	l each 22,000.00 22,000	
Miscellaneous metalwork	287,800 lbs. 0.45 129,500	
Reinforcing steel	13,350 lbs. 0.15 2,000	050 000
Control house	lump sum	279,300
Reservoir		
Clearing reservoir lands	6,200 ac. 35.00 217,000	
Relocation of utilities	lump sum 334,500	CCO E00
Access roads	lump sum1,000	552,500
Subtotal	. \$:	9,399,000

ESTIMATED COST OF SUPER HODGES DAM AND RESERVOIR WITH STORAGE CAPACITY OF 310,000 ACRE-FEET (continued)

Item	Quantity	: Unit : price	•	Cost	Ŋ.
CAPITAL COSTS					
Administration and engineering, Contingencies, 15% Real estate, land, and improvements ^a	10%				939,900 ,409,900
Relocation of state highwaysb					,601,600
Subtotal				\$30	, 599, 400
Interest during construction, 49 one-half of 3-year construction				<u>1</u>	,836,000
TOTAL				\$32,	,435,400
ANNUAL COSTS	r (Annuaga ang ang ang ang ang ang ang ang ang				
Interest, 3.5% Amortization, 40-year sinking for Operation and maintenance	und at 3.5%			\$ 1.	,135,200 383,700 25,100
TOTAL				\$ 1,	,544,000

a. Detail costs of land, improvements, and acquisition are presented in Table K-21.

b. Detail costs of state highway relocation are presented in Table K-22.

ESTIMATED COST OF SUPER HODGES-MIRAMAR CONDUIT TO ACCOMPANY RESERVOIR OF 310,000 ACRE-FEET CAPACITY

(Based on prices prevailing in 1958)

Length of conduit, in miles: 10.4
Inside diameter of pipe, in inches: 26
Design capacity of pipe, in
second-feet: 13.5
Cross-sectional area of pipe, in
square feet: 3.68

Average velocity, in feet per second: 3.66 Manning's value of "n": 0.0115 Hydraulic radius, in feet: 0.542 Hydraulic slope, in feet per foot: 0.00184

Item	: Quantity	: Unit : Price	: Co	st
CAPITAL COSTS				
Pipe Line				
Excavation, unclassified Backfill, compacted Backfill, consolidated Manholes Manhole and air valve Manhole and blowoff Vent structure Pipe, steel, mortar-lined, concrete coated, 26-inch I.D. 10-gage 8-gage	113,400 cu. yd. 8,200 cu. yd. 46,300 cu. yd. 11 each 18 each 19 each 2 each 53,300 lin.ft. 700 lin.ft.	\$ 1.20 3.00 0.75 240.00 320.00 380.00 450.00	24,600 34,700 2,600 5,800 7,200 900	
3/16-inch	700 lin.ft.	13.10	9,200 \$	834,600
Pumping Plants Cost of structures, pumps, motors, electric equip- ment and miscellaneous equipment, furnish and install				
Plant No. 1 - 850 H.P. Plant No. 2 - 600 H.P.	lump		78,500 62,000	140,500
Right of way	lump	sum	50,000	50,000
Subtotal			\$:	1,025,100

ESTIMATED COST OF SUPER HODGES-MIRAMAR CONDUIT TO ACCOMPANY RESERVOIR OF 310,000 ACRE-FEET CAPACITY (continued)

Item	0	Quantity	000	Unit Price	0	Cost	
Administration and engineering, Contingencies, 15%	1.0%						102,500 153,800
Subtotal						\$1	,281,400
Interest during construction, l construction period	% for o	na-half of l-	-yea	ır			25,600
TOTAL						\$1.	,307,000
CURRENCE/Spirit) and its quantumentatives up the functionalists of contrast decisions actions, allowed as VPMs published but 1947 Published actions and the contrast of the co	and the second second second second second						
ANNUAL COSTS							
Interest, 3.5% Amortization, 40-year sinking for operation and maintenance Electric energy for pumping TOTAL	und st.	3.5%				\$	45,700 15,500 21,300 29,100

ESTIMATED COST OF SUPER HODGES DAM AND RESERVOIR WITH STORAGE CAPACITY OF 365,000 ACRE-FEET

(Based on prices prevailing in 1958)

Elevation of crest of dam: 420 feet, U.S.G.S. datum Elevation of crest of spillway: 403 feet Height of dam to spillway crest, above

stream bed: 203 feet

Capacity of reservoir to crest of spillway: 365,000 acre-feet Capacity of spillway with 1-foot freeboard: 92,800 second-feet

	0			Unit	:		
Item	0	Quantity		: price	:	Со	st
CAPITAL COSTS							
Dam (Including spillway)							
Exploration				lump sum	\$	50,000	
Diversion of flow and							
dewatering of foundation				lump sum		25,000	
Excavation of foundation		133,100 cu.y	d.	\$ 3.50		465,900	
Concrete		1.60 000	.3	3.9 50		9 530 700	
Mass		460,200 cu.y		18.50 0.50		8,513,700	
Cooling Spillway training walls		400,200 cu.y	u.	0.50		230,100	
and piers		1,330 cu.y	d.	50.00		66,500	
Bridge and parapet walls		670 cu.y		60.00		40,200	
Reinforcing steel		200,400 lbs.		0.15		30,100	
Pressure grouting		10,400 cu.f	t.	3.00		31,200	
Drilling grout holes and							
drains		18,700 lin.	ft	. 4.00		74,800	\$ 9,527,500
Outlet Works							
Reinforced concrete		10 cu.y	a .	50.00		500	
Trash rack steel		14,800 lbs.		0.15		2,200	
Steel pipe, 48-inch dia.		62,200 lbs.		0.30		18,700	
Gate valves, 48-inch dia.				6,000.00		36,000	
High pressure slide gates		3 each	2	5,000.00		75,000	
Needle valve and energy							•
dissipator			_	0,000.00		30,000	
Miscellaneous metalwork		322,100 lbs.		0.45		144,900	
Reinforcing steel		13,350 lbs.		0.15		2,000 5,000	314,300
Control house				lump sum		5,000	314,300
Reservoir							
Clearing reservoir lands		6,950 ac.		35.00		243,300	
Relocation of utilities		• • •		lump sum		337,500	
Relocation of county roads				lump sum		79,500	
Access roads				lump sum		1,900	662,200
Subtotal							\$10,504,000

ESTIMATED COST OF SUPER HODGES DAM AND RESERVOIR WITH STORAGE CAPACITY OF 365,000 ACRE-FEET (continued)

Item	: Quantity	: Unit : : price :	Cost
CAPITAL COSTS			
Administration and enginee Contingencies, 15%			\$ 1,050,400 1,575,600
Real estate, land and impr ments ^a Relocation of state highwa	,		6,916,000 13,293,500
Subtotal			\$33,339,500
Interest during constructione-half of 3-year const			2,000,400
TOTAL			\$35,339,900
ANNUAL COSTS			
Interest, 3.5% Amortization, 40-year sink Operation and maintenance	ing fund at 3.5%		\$ 1,236,900 418,100 28,400
TOTAL			\$ 1,683,400

a. Detail costs of land, improvements, and acquisition are presented in Table K-21.

b. Detail costs of state highway relocation are presented in Table K-22.

ESTIMATED COST OF SUPER HODGES-MIRAMAR CONDUIT TO ACCOMPANY RESERVOIR OF 365,000 ACRE-FEET CAPACITY

(Based on prices prevailing in 1958)

Length of conduit, in miles: 10.4
Inside diameter of pipe, in inches: 28
Design capacity of pipe, in
second-feet: 18.0
Cross-sectional area of pipe, in
square feet: 4.3

Average velocity, in feet
per second: 4.2
Manning's value of "n": 0.0115
Hydraulic radius, in feet: 0.583
Hydraulic slope, in feet
per foot: 0.0022

Item	: Quantity	: Unit : Price	: Cost
CAPITAL COSTS		7	
Pipe Line Excavation, unclassified Backfill, compacted Backfill, consolidated Manholes Manhole and air valve Manhole and blowoff Vent structure Pipe, steel, mortar-lined, concrete coated, 28-inch I.D. 10-gage 8-gage 3/16-inch 1/4-inch	121,600 cu. yd. 8,300 cu. yd. 16,700 cu. yd. 11 each 18 each 19 each 2 each 53,000 lin.ft. 1,100 lin.ft. 1,00 lin.ft. 500 lin.ft.	\$ 1.20 3.00 0.75 240.00 340.00 430.00 490.00 12.20 12.80 13.90 16.40	\$145,900 24,900 35,000 2,600 6,100 8,200 1,000 646,600 14,100 5,600 8,200 \$ 898,200
Pumping Plants Cost of structures, pumps, motors, electric equip- ment and miscellaneous equipment, furnish and install Plant No. 1 - 950 H.P. Plant No. 2 - 650 H.P.	lump :		113,000 88,300 201,300
Right of way	lump	sum	50,000 50,000
Subtotal			\$1,149,500

ESTIMATED COST OF SUPER HODGES-MIRAMAR CONDUIT TO ACCOMPANY RESERVOIR OF 365,000 ACRE-FEET CAPACITY (continued)

	:		: Unit	•	
Item	8	Quantity	: Price	:	Cost
Administration and engineering,	1.0%				\$ 115,000
Contingencies, 15%					172,500
Subtotal					\$1,437,000
Interest during construction, 4%	for o	ne-half of 1	year		
construction period					28,700
TOTAL					\$1,465,700
ANNUAL COSTS					
Interest, 3.5%					\$ 51,300
Amortization, 40-year sinking fur	nd at	3.5%			17,300
Operation and maintenance Electric energy for pumping					21,700 37,700
TOTAL					\$ 128,000

214,200

\$

TO A STORAGE CAPACITY OF 113,600 ACRE-FEET*

(Based on prices prevailing in 1958)

(Dabe	d on prices preve	riiing in is	,0,	
Elevation of crest of dam: 680 U.S.G.S. datum Elevation of crest of spillway:	671 feet	23,400 Capacity	acre-feet of spillway v	of reservoir: with 0.5 foot
Increase in depth of water: 21	feet	freeboa	rd: 26,000 s	second-feet
		77. 11		
Thom	: Orantita	: Unit :	Cos	¬+
Item	: Quantity	: price :	COS	30
CAPITAL COSTS				
Dam (including spillway) Exploration and grouting Existing concrete preparation Excavation Mass concrete Cooling concrete	16,000 sq.yd. 36,000 cu.yd. 167,000 cu.yd. 167,000 cu.yd.	lump sum \$ 4.00 3.50 18.50	\$ 25,000 64,000 126,000 3,089,500 83,500	
Miscellaneous metalwork Reinforced concrete Reinforcing steel	129,000 lbs. 490 cu.yd. 36,000 lbs.	.45 50.00 .15	58,000 24,500 5,400	\$ 3,475,900
Outlet Works Control house construction Butterfly valve, 36-inch diam. Cone valve, 24-inch diam.	l each l each	lump sum 5,500.00 12,000.00	15,000 5,500 12,000	32,500
Reservoir				
Clearing	100 ac.	50.00		5,000
Subtotal		ŕ		\$ 3,513,400
Administration and engineering, Contingencies, 15%	10%			\$ 351,300 527,000
Subtotal				\$ 4,391,700
Interest during construction, 49 one-half of 1-year construction				87,800
TOTAL				\$ 4,479,500
ANNUAL COSTS				
Interest, 3.5% Amortization, 40-year sinking for Operation and maintenance	und at 3.5%			\$ 156,800 53,000 4,400

TOTAL

^{*} Based on data published in Bulletin No. 61 entitled, "Feather River Project, Investigation of Alternative Aqueduct Routes to San Diego County" and adjusted to prices prevailing in 1958.

ESTIMATED COST OF ENLARGEMENT OF SAN VICENTE RESERVOIR TO A STORAGE CAPACITY OF 168,200 ACRE-FEET*

(Based on prices prevailing in 1958)

Elevation of crest of dam: 724 U.S.G.S. datum Elevation of crest of spillway: Increase in depth of water: 64	714 feet	78,000 a Capacity of freeboar	in capacity of acre-feet of spillway wi rd: 26,000 se	ith 1.5 foot
Item	: Quantity	: Unit : : price :	Cos	t .
CAPITAL COSTS				
Dam (including spillway) Exploration and grouting Existing concrete preparation Excavation Mass concrete Cooling concrete Miscellaneous metalwork Reinforced concrete Reinforcing steel	16,000 sq.yd. 66,200 cu.yd. 417,000 cu.yd. 417,000 lbs. 710 cu.yd. 53,000 lbs.	lump sum \$ 4.00 3.50 18.50 .50 .45 50.00 .15	\$ 30,000 64,000 231,700 7,714,500 208,500 140,900 35,500 8,000	\$ 8,433,100
Outlet Works Control house construction Butterfly valve, 36-inch diam. Cone valve, 24-inch diam.	. 2 each 1 each	lump sum 5,500.00 12,000.00	20,000 11,000 12,000	43,000
Reservoir Clearing	300 ac.	50.00		15,000
Subtotal				\$ 8,491,100
Administration and engineering, Contingencies, 15%	10%			\$ 849,100 1,273,700
Subtotal				\$10,613,900
Interest during construction, 49 of 2-year construction period.	for one-half			424,600
TOTAL				\$11,038,500
ANNUAL COSTS				
Interest, 3.5% Amortization, 40-year sinking for Operation and maintenance	and at 3.5%			\$ 386,300 130,600 11,000
TOTAL				\$ 527,900

^{*} Based on data prepared for Bulletin No. 3 entitled, "The California Water Plan", and adjusted to prices prevailing in 1958.

TABLE K-31

ESTIMATED CAPITAL AND ANNUAL COSTS OF REQUIRED ENLARGEMENTS OF SANIVICENTE RESERVOIR UNDER POTENTIAL PLANS OF DEVELOPMENT

Required increase	: Estimated						
in storag capacity, in acre-feet	: costs ^b	Interest, 3.5%	: Amortization, : 40-year : sinking fund : at 3.5%	: Operation :	Total		
52,400	\$7,963,200	\$278,700	\$ 94,200	\$ 3,100	\$ 376,000		
49,400	7,602,800	266,100	89,900	3,000	359,000		
40,600	6,545,700	229,100	77,400	00ړو 2	308,900		
25,600	4,743,800	166,000	56,100	1,500	223,600		
11,400	3,038,000	106,300	35,900	700	142,900		

- a. Required increase in storage capacity based on coordinate operation studies of San Vicente Reservoir with existing and potential developments in the San Dieguito River watershed and with an estimated seasonal import of 75,450 acre-feet.
- b. Based on straight-line relationships between costs of the two specific enlargements detailed in Tables K-29 and K-30.

State of California Department of Public Works

DIVISION OF HIGHWAYS

March 7, 1956

Please refer to file No.

XI-SD-197-A, B

Mr. David Powell Division of Water Resources Spreckels Building San Diego, Calif.

Dear Mr. Powell:

At your request, we have studied the effect on State highways of the proposed San Pasqual reservoir as outlined on the maps which you furnished this office.

The construction of the San Pasqual reservoir either to elevation 440 or elevation 520 would require the re-location of substantial portions of State Sign Route 78, our road XI-SD-197-A,B. Because of the two arms of the reservoir extending northerly and because of the rugged nature of the country, it would be very difficult to re-locate the highway along the northerly side of the reservoir.

It might be possible to re-locate the highway just south of the "dam site" and through Highland Valley easterly to Ramona. This would involve a great length of new highway through very rough country and would entail steep grades.

The most practical location appears to utilize the old U. S. 395 southerly from Lake Hodges to the County road through Green Valley and then easterly to a point near Rancho Del Sueno. From this point easterly, an entirely new location for a length of 5.3 miles would be required. It would carry the road to a connection with State Sign Route 67 at the Mount Woodson turn approximately 6 miles west of Ramona. Estimated cost of this new construction for 5.3 miles and some reconstruction of 2.5 miles from County road through Green Valley is estimated to cost \$900,000.00.

Please advise if any additional information is required.

Yours very truly,

J. DEKEMA District Engineer

BY /s/ R. A. Hayler
R. A. HAYLER
Assistant District Engineer

cc:M.Bookman Div. of Water Res., L.A. RAL RAH February 14, 1958

Mr. J. Dekema, District Engineer District XI Division of Highways State Department of Public Works 4075 Taylor Street San Diego 12, California

Dear Mr. Dekema:

This Department is currently engaged in a two-year water resources investigation in the San Dieguito River watershed in San Diego County, which is being conducted in cooperation with the City of San Diego. Our report of investigation will include recommendations as to locations, sizes, and costs of dams, reservoirs, and conveyance facilities within the watershed, including costs of relocating roads. Construction of dams at the Super Hodges and San Pasqual "A" sites would, during certain periods, result in inundation of portions of U. S. Highway No. 395 and State Sign Route No. 78. Several sizes of dams are being studied at each of these two sites, and the elevations of the spillway and dam crests are as follows:

	Elevations,	in feet
Reservoir site	Spillway crest	Dam crest
San Pasqual "A"	413 445 470	433 465 490
Super Hodges	365 395 403	384-388* 413-417* 420-424*

^{*} Final choice depends on type of structure (concrete or rockfill) due to difference in residual freeboard allowance.

Approximate locations of axises of proposed dams and the contour elevation equal to the dam crest elevation for the highest dam under consideration are shown on the attached U. S. Geological Survey quad.

Your letter of March 7, 1956, File No. XI-SD-197-A, B, transmitted to Mr. D. O. Powell of this Department estimates of cost of necessary highway and bridge relocation as a result of construction of a proposed dam at the San Pasqual "A" site. Mr. G. T. McCoy's letter dated February 10, 1953, to the State Engineer, State Division of Water Resources, File No. 200.47 B 8, furnished the same information for the Super Hodges dam site. In view of changing price levels and the sizes of dams being considered, it is necessary to modify and augment relocation cost information you previously supplied this Department. It is respectfully requested that the costs of relocating the afore-mentioned highways, based on 1957 prices, as a result of construction of each of the dams listed heretofore, be estimated and furnished this office. Separate costs for major bridge structures would be highly desirable. Your prompt consideration of this request will be greatly appreciated since our studies and report must be completed by June 30, 1958.

Mr. J. O. McClurg, Associate Hydraulic Engineer and Resident Engineer for the San Dieguito River Investigation, is in charge of our investigation field office located at 218 East Grand Avenue, Escondido, (telephone number: SHerwood 5-5998). Mr. McClurg will contact your office in the near future to facilitate the preparation and transmittal of the desired cost data.

Very truly yours,

HARVEY O. BANKS Director of Water Resources

By /s/ Max Bookman Max Bookman District Engineer

Encs.

INTER-DEPARTMENTAL COMMUNICATION

DATE: May 6, 1958

Mr. Harvey O. Banks

TO: Director

FILE NO. XI-SD-77, 197-B, A, B

Department of Water Resources

FROM: Division of Highways

In letter dated February 14, 1958, Mr. Max Bookman requested information from the Division of Highways regarding updated costs for State highway relocations in the vicinity of Super Hodges and San Pasqual "A" Reservoirs in San Diego County. Estimated costs on the basis of 1957 prices for the State highways affected by these water projects are as follows:

SUPER HODGES

Route	Roadway & R/W	Structures	Total
XI-SD-77-B	(4 lanes, spillway \$2,747,000	elev. 365) \$1,843,000	\$ 4,590,000
	(4 lanes, spillway \$3,645,000	elev. 395) \$7,288,000	\$10,933,000
	(4 lanes, spillway \$3,886,000	elev. 403) \$7,288,000	\$11,174,000

The Division of Highways has a project now in the planning stage to convert Route 77 to four lanes at this location, and it is for this reason the above estimates each reflect cost to remove a 4-lane facility from reservoir backwater.

The above estimates assume that the new one-way bridge at Green Valley Creek will clear high water from spillway crest elevation 403. If studies subsequently indicate an excess cost to State highway funds for this clearance, a low level structure will be built, in which event each of the above three estimates will have to be increased by \$625,000 to provide a new bridge for clearance of the backwater pool.

Super Hodges construction will also affect the State highway between Escondido and Ramona. Estimated cost of reconstructing this route to clear the three reservoir levels is as follows:

SUPER HODGES, Cont.

Route	Roadway & R/W	Structures	Total
XI~SD~197~A,B	(2 lanes, spillway \$ 67,000	elev. 365) \$	67,000
	(2 lanes, spillway \$ 473,000	elev. 395) \$ \$ 50,000	523,000
	(2 lanes, spillway \$ 851,000	elev. 403) \$ \$ 60,000	911,000

San Pasqual "A" Reservoir affects only the State highway between Escondido and Ramona. Estimated cost of relocation, contemplating reconstruction generally north of the existing State highway, is as follows:

SAN PASQUAL "A"

Route	Roadway & R/W	Structures	Total
XI-SD-197-A,B	(2 lanes, spillway \$1,117,000	elev. 413) \$ 77,000	\$1,194,000
	(2 lanes, spillway \$7,564,000	elev. 445) \$ 286,000	\$7,850,000
	(2 lanes, spillway \$9,303,000	elev. 470) \$ 335,000	\$9,638,000

All foregoing estimates are reconnaissance in nature and are subject to such revision foundation tests, classification of materials and instrument surveys would require. Engineering costs are not included in the figures.

ORIGINAL SIGNED BY G. T. McCOY

May 6, 1958

G. T. McCoy State Highway Engineer . Mr. G. T. McCoy State Highway Engineer Division of Highways Department of Public Works 1120 N Street Sacramento, California June 6, 1958

X1-SD-77, 197-B, A, B

Cost of Relocation of Highways in San Dieguito River Watershed in San Diego County

Attention: Mr. R. V. Potter

Reference is made to your inter-departmental communication of May 6, 1958, transmitting an estimate of cost of relocating State Highway Nos. 395 and 78 in the vicinity of Super Hodges and San Pasqual Reservoir sites on the San Dieguito River in San Diego County. Receipt of this information was acknowledged by our inter-departmental communication of May 20, 1958.

A review of your estimate of the cost of relocation of State Highway No. 78, which would be required by construction of San Pasqual Dam and Reservoir with water surface elevation of 413, 445, and 470 feet, indicates that the new highway route you have selected extends along the north side of San Pasqual Valley and would cost \$9,638,000 for the 470-foot reservoir elevation. Your letter dated March 7, 1956, signed by Mr. J. Dekema, District Engineer, District X1, Division of Highways, San Diego, a copy of which is attached hereto, discussed relocation of State Highway No. 78 along the north side of San Pasqual Valley, and through Highland and Green Valleys. Your letter concluded that:

"The most practical location appears to utilize the old U.S. 395 southerly from Lake Hodges to the County road through Green Valley and then easterly to a point near Rancho Del Sueno. From this point easterly, an entirely new location for a length of 5.3 miles would be required. It would carry the road to a connection with State Sign Route 67 at the Mount Woodson turn approximately 6 miles west of Ramona. Estimated cost of this new construction for 5.3 miles and some reconstruction of 2.5 miles from County road through Green Valley is estimated to cost \$900,000.00."

It is understood from a telephone conversation with Mr. R. V. Potter of your Sacramento office that the current cost estimate is based on the costly northerly alignment because the existing route, adopted by the State Highway

Mr. G. T. McCoy

Commission, is north of San Pasqual Valley. Examination of United States Geological Survey topographic maps at a scale of 1:24,000 indicates that a route from Escondido to Ramona through Green Valley would exceed the length of the present route by approximately seven miles, while a route through Highland Valley would exceed the length of the present route by three miles. In view of the differential in cost of over \$8,000,000 between your estimates for the northerly and Green Valley routes, it would appear unreasonable and unrealistic for this agency to assume that the northerly route would ever be constructed.

Selection of the surface storage development to be constructed in the San Dieguito River watershed will be based on cost and yield comparisons. Naturally, an addition of \$8,000,000 to the cost of the San Pasqual project might well exclude it from further consideration. Since our final report of investigation is scheduled for completion by June 30, 1958, preparation of a detailed estimate of current cost of relocation through either Green or Highland Valleys is not feasible. However, it would be greatly appreciated if you would provide this Department with a communication for our files setting forth your reasons for selecting the northerly route rather than the less costly routes through Green and Highland Valleys recommended by your Division previously.

HARVEY O. BANKS
Director of Water Resources

By /s/ Max Bookman
Max Bookman
District Engineer

State of California Sacramento 7

INTER-DEPARTMENTAL COMMUNICATION

Mr. Harvey O. Panks

DATE: July 2, 1958

To: Director

Department of Water Resources FILE NO. XI-SD-77, 197-B,A,B

FROM: Division of Highways

This refers to communication dated June 6, 1958, signed by Mr. Max Bookman, regarding estimates of cost for relocating legislative Route 197, between Ramona and Escondido, in event of construction of San Pasqual Dam and Reservoir. Explanation is requested why the Division of Highways reports a relocation of highway route confined to northerly side of San Pasqual Valley, when a communication from the Division of Highways in 1956 mentioned relocations by way of Highland Valley and Green Valley at less cost.

The present road between Escondido and Ramona was added to the State Highway system by legislative act. In reporting to your office cost of adjustment needed in State highway to clear reservoir elevation 470 it is necessary that the Division confine its estimate to this official route, notwithstanding the fact that possibilities exist in this area for alteration to the State highway system in the event of reservoir construction.

The information furnished your office in 1956 regarding cost of the Green Valley route is significant and it is recognized that it may be in the public interest for the water project sponsors to advocate construction along this route at a savings to the reservoir project.

It is our opinion, however, that the relocation of legislative Route 197 along Green Valley would not comply with the present legislative description of this route; therefore, action by the Legislature would be required before such a routing could be adopted.

To avoid any misunderstanding in this respect, our reply to your office was confined to a relocation in the vicinity of the existing route that would comply with the present satutory description with full knowledge of the greater initial first cost as compared to a relocation along Green Valley.

> /s/ G. T. McCoy G. T. McCoy State Highway Engineer

October 6, 1958

COPY

Main Office Civic Center San Diego 1, California

Room 273, Civic Center

Mr. Max Bookman
Dept. of Water Resources
P. O. Box 15718
Los Angeles, California

Subject: San Dieguito Area Study

Dear Mr. Bookman:

In accordance with your recent request, we are enclosing the following documents:

- l. Historical costs of facilities on the San Dieguito system. The date of acquisition, description and original cost is indicated. Many items in the lower portion of the system are included but are sufficiently detailed so that you may eliminate them as necessary.
- 2. A copy of the right of way contract between the State of California Division of Highways and the City of San Diego for the construction of the two lane bridge on Highway 395 across Lake Hodges and also a letter from the Ass[§] t. City Manager, Mr. Blom, dated Sept. 11 referring to the bridge construction.
- 3. A copy of the Wehe report analyzing the cost of water and the rate structure adopted by the City last Spring.

If further information is desired, please feel free to contact this office.

Very truly yours,

/s/ R. E. Graham R. E. Graham Utilities Director

REG:bs

enc.

(Enclosure to letter from City of San Diego Water Department, dated October 6, 1958)

COPY

September 11, 1953

Mr. E. E. Wallace, District Engineer State Division of Highways P. O. Box 390 San Diego 12, California

Subject: Hodges Reservoir Bridge

Dear Mr. Wallace:

Reference is made to discussions concerning a high level and temporary low level bridge on U. S. Highway 395 across Hodges Reservoir and especially the timing of possible construction of a Super-Hodges Dam which would inundate any temporary low level construction.

Some inquiry was made as to the possibility of the City of San Diego reimbursing the State for the City's share of such high level bridge should it be built now, on account of a future Super-Hodges Dam.

Inquiry was also made as to whether the City would be willing to grant a permit for the construction of a temporary low level structure across City-owned lands, which structure would consist of approach fills and a bridge of the piling and deck type with openings aggregating about 200 feet in length.

The question of timing of Hodges construction completion is shown on our drawing File No. 3825, "City of San Diego, California, Population and Water Requirements". It is indicated thereon that in the normal course of events the reservoir might be completed sometime between 1962 and 1969. The construction of this additional development is interdependent with policies of the San Diego County Water Authority who are the agency importing Colorado River water for use by the City of San Diego as well as other agencies. The timing is also affected by the Metropolitan Water District's statement of policy that they will supply the needs of this area. If this policy can be carried out it may be less expensive for the City to secure additional water supplies through the San Diego County Water Authority than by the development of Hodges or other local reservoirs.

Furthermore, the First and Second Barrels of the San Diego Aqueduct will bring into this area about 150,000 acre feet of water annually of which the City is entitled to about 75%. If the Metropolitan Water District is able to supply the needs, as they indicate, the City would be entitled out of this amount to

about 112,000 acre feet annually which when added to the local development of upwards of 40,000 acre feet annually will provide for the City about 150,000 acre feet. This, according to the chart previously referred to, will meet our needs until about 1970.

It appears to be reasonably certain that the Super-Hodges development will not be made within a ten year period.

If a high level bridge is built at this time, the City cannot obligate itself to reimburse the State for any funds which may have been advanced on the City's account. The City would have no objection to a temporary low level road and bridge to replace the present structure and alignment, which has resulted in so many accidents, providing the City's obligation in connection with a future high level bridge is not affected in any way by the construction of this temporary low level realignment. On this basis, the City would be willing to grant an encroachment permit over City—owned land.

There is no objection to leaving the existing bridge in place and when a high level bridge is built it would only be necessary to remove a relatively minor portion of the proposed temporary bypass so as to permit access to the upper end of the reservoir by boats.

There will also be no objection to the State excavating materials from within the basin at approved location for making the access fill.

Very truly yours,

E. W. Blom Assistant City Manager

PB/f cc Director, Water Dept.

(Enclosure to letter from City of San Diego Water Department, dated October 6, 1958.)

COPY

RIGHT OF WAY CONTRACT -STATE HIGHWAY

Document No. 6013 in the form of an easement for public highway purposes, covering the following described property, hereinafter called "New Property":

a portion of Lake Hodges Reservoir

has been executed and delivered to the <u>DIVISION OF HIGHWAYS</u> of the State of California.

In consideration of which, and the other considerations hereinafter set forth, it is mutually agreed as follows:

1. The parties have herein set forth the whole of their agreement. The performance of this agreement constitutes the entire consideration for said document and shall relieve the State of all further obligation or claims on this account, or on account of the location, grade or construction of the proposed public improvement.

2. The State shall:

Pay to grantor the actual cost of relocating the following described improvements from said "New Property" to a new location outside thereof, and will make such payment within 60 days after receipt of bills in triplicate from grantor showing the detailed cost of said work. The estimated cost of said relocation of improvements is \$10,000, however it is recognized that actual cost may be more or less than said amount.

Said work shall consist of moving house and attached garage; building house foundation; building septic tank and diffusion line; dismantle and rebuild water tank; drill new well and connect to tank; replace storehouse and garage; salvaging operations; electrical and plumbing connections and charges by the San Diego Gas and Electric Company and Pacific Telephone and Telegraph Company for the cost of installing new service connections to the above-described improvements in their relocated positions. In addition to the above charges, the State shall pay the cost of supervision and engineering required for said work.

- 3. It is understood by the parties hereto that it is the present intention of the State to construct and maintain a public highway and bridge upon the said "New Property" as shown on those certain plans entitled *Plan and Profile of State Highway in San Diego County, at Lake Hodges signed by G. T. McCoy and Frank B. Durkee and dated April 19, 1954, which said plans, consisting of 65 sheets, are now on file at the office of the State Highway Engineer, State Division of Highways, 1120 N Street, Sacramento, California. A typical cross-section of said improvement is attached hereto marked Exhibit "A", and by this reference incorporated herein. It is also understood by the parties that construction of said public highway and bridge will result in a new alignment of State Highway Route 77; however, State, at its option, will retain the existing bridge and approaches now in place on the present alignment and will make such use thereof as it sees fit.
- grantor of the aforesaid document No. 6013 it is expressly agreed that in the event grantor at any time enlarges the impounding capacity of Lake Hodges Reservoir by the construction of a new dam or the enlarging of the present dam or by any means floods said "New Property", that then and in that event the obligation of grantor to contribute to the cost of relocating the highway improvements then in place upon said "New Property" shall in no event exceed the sum it would be required to contribute for the relocation, replacement and raising of the improvements now contemplated by State, as shown on those certain plans hereinbefore referred to as being on file at the office of the State Highway Engineer, State Division of Highways in Sacramento and as shown in typical detail upon the attached Exhibit "A". In the event of said flooding State hereby expressly waives all right to contribution from grantor it might

other ise be entitled to for the relocation and replacement of the existing bridge now in place on the present alignment and for the relocation and replacement of such portions of the approaches to said existing bridge as are not utilized in the new alignment. It is distinctly understood that said waiver is strictly limited to the State's right to contribution for flooding of said existing bridge and approaches and does not extend to such contribution from grantor as State would be entitled to by the flooding of said "New Property" and the necessary relocation and replacement of the new highway and bridge to be built thereon. (Emphasis added.)

IN WITNESS WHEREOF, on this 27th day of May, 1954 this Agreement is executed by the City, acting by and through the City Manager, under and pursuant to Resolution No. 118100, authorizing such execution, and the State of California has executed this Agreement by its Department of Public Works, Division of Highways.

THE CITY OF SAN DIEGO,
Grantor

By /s/ O. W. Campbell
Assistant City Manager

STATE OF CALIFORNIA
Department of Public Works
Division of Highways

By /s/ E. E. Wallace

Recommended for Approval,

By /s/ John Ritz
Right of Way Agent

Recommended for Approval,

By /s/ John C. Webb
District Right of Way Agent

I HEREBY APPROVE the form and legality of the foregoing Agreement, this 27th day of May, 1954.

DuPAUL, City Attorney

/s/ J. F. DuPaul

Deputy City Attorney

No Obligation Other Than Those Set Forth Herein Will Be Recognized



APPENDIX L

RESULTS OF
RELATED RESERVOIR OPERATION STUDIES

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APPENDIX L

RESULTS OF RELATED RESERVOIR OPERATION STUDIES

Introduction

Values of safe yield of existing and potential reservoirs within the San Dieguito River watershed were estimated both on the basis of operation of facilities solely within the watershed and with coordinate operation of San Vicente Reservoir. Values of safe yield estimated in this manner are presented in Chapters IV and VI of the text of the report. In addition and pursuant to the agreement authorizing this investigation, values of safe yield of major developments located outside the San Dieguito River watershed affecting the City of San Diego were determined and are presented in this appendix. Values of average storage, surface area, and length of shore line of Lake Hodges under various assumed operating conditions are also set forth in this appendix.

Major Reservoirs Outside the San Dieguito River Watershed That Affect the City of San Diego

The major water supply facilities in San Diego County outside the San Dieguito River watershed that affect the City of San Diego are reservoirs comprising the San Diego River system and the Cottonwood Creek-Otay River system. The safe yields of these systems, along with the criteria employed in the determination of these yields, are discussed herein.

San Diego River System

The three major water conservation reservoirs located in the San

Diego River system are the City of San Diego's San Vicente Reservoir on San Vicente Creek and El Capitan Reservoir on the San Diego River and Helix Irrigation District's Cuyamaca Reservoir on Boulder Creek. Locations of these reservoirs are shown on Plate 14 of the text.

The confluence of San Vicente Creek and the San Diego River is located below El Capitan and Cuyamaca Reservoirs and the operation of these two reservoirs does not directly affect San Vicente Reservoir. It is possible to transfer water through conduits between El Capitan and San Vicente Reservoirs, in either direction, depending on water levels in the two reservoirs; however, representatives of the City of San Diego have stated that it is not their normal policy to transfer water between these reservoirs. Operation of San Vicente Reservoir in conjunction with Sutherland Reservoir located on Santa Ysabel Creek in the San Dieguito River watershed, and yields derived therefrom, are discussed in detail in Chapters IV and VI of the text and, therefore, will not be discussed further.

Representatives of the Helix Irrigation District report that the District has a right to a total gross average annual diversion of 10,000 acre-feet from the San Diego River (regardless of source or method) over a ten-year period, with the rate of diversion upstream from El Capitan Reservoir not to exceed 27 second-feet. The District also has a contract with the City of San Diego under the terms of which the District may store water in El Capitan Reservoir, located downstream from Cuyamaca Reservoir, in amounts up to 10,000 acre-feet. The District also reports it has a right to temporarily store Cuyamaca Reservoir water in El Capitan Reservoir each year, from May 1, to October 31.

The safe yield of El Capitan Reservoir was estimated, by means of

a manual reservoir operation study, on the basis of the following assumptions:

- 1. El Capitan and Cuyamaca Reservoirs would be full on May 1, 1944, and the period May 1, 1944, through January 31, 1958, was considered critical with respect to safe yield reservoir operations.
- 2. Water in storage in Cuyamaca Reservoir would be transferred to El Capitan Reservoir each spring.
- 3. Reservoir evaporation losses would be apportioned between the City and the District according to the amount of water stored by each party.
- 4. No more than 10,000 acre-feet of Helix Irrigation District water would remain in El Capitan Reservoir after October 31. During years in which the amount of District water stored in El Capitan Reservoir would exceed 10,000 acre-feet on the basis of a uniform seasonal draft, withdrawals from the reservoir by the District would be increased to the extent necessary to result in a storage of 10,000 acre-feet of District water on October 31.
- 5. The monthly draft from El Capitan Reservoir was based on the monthly distribution of seasonal water demand by the City of San Diego, as presented in Table 12 of the text.

Estimates of runoff at the reservoirs were based on records furnished by the United States Geological Survey, the City of San Diego, and the Helix Irrigation District. Where records were not available, estimates in Bulletin No. 48 entitled "San Diego County Investigation", 1935, were used.

Based on the previous assumptions, the safe seasonal yield from El Capitan Reservoir to the City of San Diego was estimated to be 9,800 acre-feet.

Cottonwood Creek-Otay River System

Four water conservation reservoirs, all owned and operated by the City of San Diego, comprise the Cottonwood Creek-Otay River system. Locations of Upper and Lower Otay Reservoirs located on the Otay River and Morena and Barrett Reservoirs located on Cottonwood Creek are shown on Plate 14 of the text. Although Cottonwood Creek is not a tributary of the Otay River, these four reservoirs must be treated as one system in much the same manner as are Sutherland and San Vicente Reservoirs since water is transferred through Dulzura Conduit from the Cottonwood Creek reservoirs to Dulzura Creek, a tributary of Jamul Creek, which is tributary to the Otay River above the Otay Reservoirs. From these reservoirs water enters the distribution system of the City of San Diego.

Due to the relatively small size of Upper Otay Reservoir in relation to Lower Otay Reservoir and since only the total runoff to both reservoirs is reported in the available United States Geological Survey runoff records, these two reservoirs were assumed for purposes of the yield studies to be a single reservoir. With this in view, the upper portion of the area-capacity curve for Lower Otay Reservoir was modified to include Upper Otay Reservoir, and it was assumed in estimating evaporation losses that storage in the two reservoirs would be depleted in equal amounts until Upper Otay Reservoir was depleted.

The combined safe yield from Barrett and Morena Reservoirs was determined, using electronic computing machines, on the following basis: (1) balanced storage; and (2) the system draft was applied on the lower or Barrett Reservoir first while maintaining Morena Reservoir full until such time as the dead storage level was reached in Barrett Reservoir, after which time the combined draft was applied to Morena Reservoir. Dead storage level in

Barrett Reservoir was maintained by diverting subsequent inflow and reducing the draft on Morens Reservoir by this amount. It was necessary to estimate the safe yield from these two reservoirs by both methods since it was not apparent by inspection which type of operation would produce the greatest yield. The second method of operation whereby the combined system draft is first applied on Barrett Reservoir resulted in about 1.4 per cent more safe yield than the first method using the balanced storage concept, and provided a combined safe yield of 7,100 acre-feet per year.

The net evaporation loss per acre-foot of storage in Morena Reservoir is greater than that at Barrett Reservoir, but it is believed that any savings in water resulting from reduced evaporation effected by releasing stored water from Morena Reservoir, would be more than offset over a long-time mean period by the increased loss of water spilling from Barrett Reservoir while storage space was available in Morena Reservoir.

Comparison of the results of the Otay and Morena-Barrett Reservoir operation studies disclosed that storage space was available in Otay Reservoir while water was spilling from Barrett Reservoir. The safe yield from Otay Reservoir was then recomputed assuming utilization of the unused conveyance capacity of the Dulzura Conduit to increase the transfer of water from Barrett Reservoir to Otay Reservoir during times of spill in Barrett Reservoir in a manner similar to that described in Chapter IV and VI of the text for Sutherland and San Vicente Reservoirs. The safe seasonal yield of Otay Reservoir when considering the transfer of a portion of the spills from Barrett Reservoir was estimated to be 5,200 acre-feet, or 200 acre-feet more than when spills are not considered. The total combined safe seasonal yield from the Cottonwood Creek-Otay River System is, therefore, estimated to be 12,300 acre-feet.

The combined monthly draft from Otay, Morena, and Barrett Reservoirs was based on the monthly distribution of seasonal water demand by the City of San Diego, as presented in Table 12 of the text. Estimates of runoff at the reservoirs was based on records furnished by the United States Geological Survey and the City of San Diego. It was assumed for purposes of the safe yield determinations that the three reservoirs would be full on April 1, 1943.

Values of safe yield of major reservoirs located outside the San Dieguito River watershed affecting the City of San Diego and the estimate of safe yield of existing surface storage facilities in the watershed are presented in Table L-1.

TABLE L-1

COMBINED SAFE SEASONAL YIELD OF RESERVOIRS
AFFECTING THE CITY OF SAN DIEGO

Reservoir : Sa	afe seasonal yiel	d, in acre-feet
Sutherland) Hodges) San Vicente*		8,200
Natural runoff Diverted spills from Sutherland Reservoir El Capitan Morena Barrett	5,200 900	6,100 9,800 7,100
Upper and Lower Otay Natural runoff Diverted spills from Barrett Reservoir TOTAL	5,000 200	<u>5,200</u> 36,400

^{*} Does not include imported water.

Results of Other Operations of Hodges Reservoir

To aid the City of San Diego in evaluating various operations of Hodges Reservoir, particularly in regard to yields and recreational benefits based on average reservoir storage, surface area, and shore line, the following reservoir operation studies were conducted for the period 1914-15 through 1956-57 as a result of a specific request of the City of San Diego:

- 1. Combined safe yield operation of Hodges and Sutherland ... Reservoirs.
- 2. Safe yield operation of Hodges Reservoir assuming a secondary yield operation of Sutherland Reservoir.
- 3. Secondary yield operation of Hodges Reservoir assuming a secondary yield operation of Sutherland Reservoir.
- 4. Safe yield operation of Hodges Reservoir assuming that Sutherland Reservoir had not been built.

The area-capacity relationships presented in Table 28 of the text and the net seasonal unit evaporation rate set forth in Table 29 of the text were used in all four operation studies. The dead storage capacity was assumed to be 3,000 acre-feet for the first three studies and 4,800 acre-feet for the fourth study in which it was assumed that Sutherland Reservoir had not been constructed. Dead storage capacities were estimated from anticipated rates of sedimentation which were based on historic losses in storage at Hodges Dam.

Estimates of the mean seasonal runoff "Between Sutherland Dam and Hodges Dam" are presented in Appendix D and were used in the first three studies of Hodges Reservoir operation. To these values of runoff

entering Hodges Reservoir were added volumes of spill from Sutherland Reservoir to determine total inflow to the reservoir. The City of San Diego operates Sutherland Reservoir on a secondary yield basis as described in Chapter IV of the text. With this method of operation, spill would occur in only two months during the 1915-16 season assuming the reservoir empty at the beginning of the study period, 1914-15 through 1956-57. Records of historic runoff to Hodges Reservoir, adjusted for the effect of Sutherland Reservoir commencing with the 1953-54 season were utilized in the fourth study in which it was assumed that Sutherland Reservoir had not been constructed.

In the first study, the combined safe yield operation of Hodges and Sutherland Reservoirs, it was assumed that the combined safe yield of the two reservoirs would be applied first as a draft on Hodges Reservoir until dead storage level was attained or the demand exceeded the diversion capacity of the conveyance works from Hodges Dam, and second as a draft on Sutherland Reservoir. Diversions from Hodges Reservoir would take place when necessary to maintain the dead storage level in that reservoir. With this type operation, the seasonal system draft is the same every year but will not be the same each year for any particular reservoir. The system draft for any particular month is the same every year and is based on the average monthly distribution of seasonal urban demand by the City of San Diego as shown in Table 12 of the text.

In the second study, the safe yield operation of Hodges Reservoir, with Sutherland Reservoir operated on a secondary yield basis, the draft is the same every year and is the same for any particular month in

every year based on the afore-mentioned average monthly distribution of seasonal urban demand by the City of San Diego.

In the third study, the secondary yield operation of Hodges and Sutherland Reservoirs, diversions from Hodges Reservoir are assumed to be effected at a rate equal to the conveyance capacity of the conduit between Hodges and San Dieguito Reservoirs. It was assumed that water would be diverted between Sutherland and San Vicente Reservoirs at rates commensurate with storage levels in Sutherland Reservoir. The secondary yield of Hodges Reservoir varied from a minimum of zero for six years to a maximum of about 15,900 acre-feet per year for sixteen years during the study period, 1914-15 through 1956-57.

Assumptions used in the fourth study which evaluated the safe yield of Hodges Reservoir, assuming Sutherland Reservoir had not been built, were the same as those used in the second study, safe yield operation of Hodges Reservoir with Sutherland Reservoir operated on a secondary yield basis, except that the allowance for dead storage was estimated to be 4,800 acre-feet. The estimate was based on the condition that sediment would not be deposited in Sutherland Reservoir and that the runoff entering Hodges Reservoir would be equal to the historic flow adjusted for the actual effect of Sutherland Reservoir since it was first operated in 1954. Hodges Reservoir was assumed to be full in April, 1943, and the study period was taken to be 1942-43 through 1956-57.

Reservoir storage capacity, dead storage, runoff, and evaporation data pertaining to the nine reservoirs for which operations are described herein appear in Table L-2. Average seasonal inflow, draft, spill, evaporation, and storage for Hodges Reservoir for the four types of reservoir operations described herein are presented in Table L-3, while a summary of seasonal storage, surface area, and length of shore line for Hodges Reservoir for the first three operation studies is set forth in Table L-4.

SUMMARY OF DATA USED IN RESERVOIR OPERATION STUDIES

TABLE L-2

. Hodges "Sutherland, San Vicente, Cuyamaca "El Capitan, Morena "Barrett "Lower Otay Reservoir, Reservoir, Reservoir, Reservoir, Reservoir, Reservoir, Reservoirs	0 112,810 50,210 44,730 59,340	500 3,900 4,900 2,600 1,980	30,000 ^e 1.2,000 14,800 ^f 10,400	5 4.33 3.65 3.61 3.12
rland, San Vicente, Cuyama rvoir, Reservoir Reserv	29,680 90,230 11,540	1,800 3,290 5	14°,000 7°,800 μ,400	2,61 3,98 3,55
Hodges Suthe	d d	3,000°	24,400d	2.79
Item	Gross reservoir storage capacity, in acre-feeta	Dead storage allowance, in acre-feet ^b	Estimated mean seasonal runoff for the period 1914-15 through 1956-57, in acre-feet	Average net seasonal rate of evaporation, in feet

Based on data obtained from the City of San Diego and the Helix Irrigation District. ကို ကို

Based on anticipated sedimentation rates except for San Vicente and Lower Otay Reservoirs for which dead storage values were based on the minimum elevation required for satisfactory operation according to the City of San Diego.

The value of dead storage used in the study in which it was assumed that Sutherland Reservoir had not been built was 4,800 acre-feet. ပံ

Runoff originating between Sutherland and Hodges Reservoirs assuming present conditions of land and water use in San Pasqual-Main Lake Hodges Basin. တွ

Runoff originating between Cuyamaca and El Capitan Reservoirs. r e

Runoff originating between Morena and Barrett Reservoirs.

TABLE L-3

SUMMARY OF VARIOUS OPERATIONS OF HODGES RESERVOIR FOR THE PERIOD 1914-15 THROUGH 1956-57

	In Acre-Feet				
Method of operationa	: Average : Average : Average : seasonal : seasonal	Average : seasonal :	: Average :	Average : Average seasonal	* Average * seasonal
4	: inflow : draft	draft:		: evaporation : storage	storage
Combined safe yield operation of Hodges and Sutherland Reservoirs	35,200 ^b	7,100°	26,300	2,400	21,500
Safe yield operation of Hodges Reservoir with secondary yield operation of Sutherland Reservoir	也。 500 ^b	2,400d	19,300	2,800	25,600
Secondary yield operation of Hodges Reservoir with secondary yield opera- tion of Sutherland Reservoir	24,500 ^b	9,200 ^d	13,700	1,600	12,700
Safe yield operation of Hodges Reservoir assuming Sutherland Reservoir had not been builte	38,000€	3,800	1 1 1 8 6	- Not computed	8 8 8 8 8

Assuming present land and water use in San Pasqual-Main Lake Hodges Basin. **ช**

Includes spill from Sutherland Reservoir. b. Average draft from Hodges Reservoir with combined safe seasonal yield from Hodges and Sutherland Reservoirs of 8,200 acre-feet.

Mean seasonal secondary yield of Sutherland Reservoir estimated to be 12,900 acre-feet. င္

Period of operation was from April, 1943, through September, 1957. Average spill. net evaporation, and storage for the 43-year mean period were not computed. Historic runoff adjusted for effect of Sutherland Reservoir from 1953-54 through 1956-57. ů

TABLE L-4

SUMMARY OF SEASONAL STORAGE, SURFACE AREA, AND LENGTH OF SHORE LINE OF HODGES RESERVOIR FOR VARIOUS METHODS OF OPERATION FOR THE PERIOD 1914-15 THROUGH 1956-57

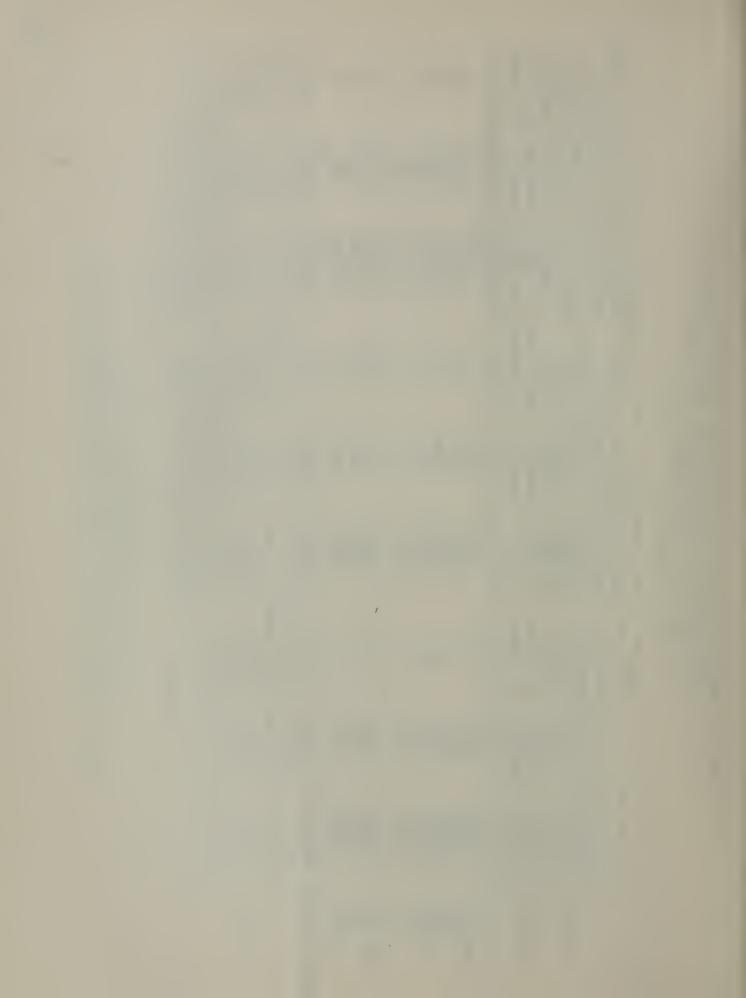
	00		Method		1 1		operation		
	Combined sa	ife yield o	Combined safe yield operation of Hodges and Sutherland Reservoirs	: Safe yield : Reservoir : operation	Safe yield operation of Hodges Reservoir with secondary yield operation of Sutherland Reserv	Safe yield operation of Hodges Reservoir with secondary yield operation of Sutherland Reservoir	eo eo ee		yield operation of Hodges with secondary yield of Sutherland Reservoir
Season		Average surface area for season, in acres	Average: length of shore line for season; in miles		<pre>: Average : surface : area for : season, : in acres</pre>	:Average : :length of : :shore line : :for season; : :in miles :	00 00 00 00		:Average :length of :shore line :for season, :in miles
1914-15 -16 -17 -18 -18	20,600 31,400 31,700 29,400 23,300	860 1,180 1,200 1,120	16 20 20 19 17	21,100 31,800 32,200 30,800 27,800	870 1,190 1,210 1,160 1,080	16 20 21 20 19	18,500 28,700 28,000 25,200 11,000	780 1,110 1,080 1,000	15 19 13 13
1919-20 -21 -23 -23 -24	22,900 19,600 29,600 30,800 24,700	930 820 1,140 1,170 980	1.7 1.6 20 20 1.8	24,300 20,800 30,300 31,600 28,700	980 870 1,150 1,190	118 20 20 1.9	2,300 20,700 20,500 6,600	230 200 1,000 850 350	7 118 16 9
1924-25 -26 -27 -28 -29	17,100 21,100 30,400 28,700 23,900	730 870 1,160 1,110	15 10 10 18	24,700 26,300 31,200 31,000 28,800	990 1,040 1,180 1,170	118 20 20 19	2,900 8,000 22,600 19,500 6,000	210 h00 920 810 340	10 117 16
1929-30 -31 -32 -33 -34	22,500 20,500 26,800 30,800	920 850 1,060 1,170 980	17 16 19 20 18	28,100 27,300 30,100 31,900 28,900	1,090 1,080 1,150 1,200 1,10	19 20 20 19	3,300 2,900 20,900 21,100 7,600	230 210 870 880 400	7 16 17 10

SUMMARY OF SEASONAL STORAGE, SURFACE AREA, AND LENGTH OF SHORE LINE OF HODGES RESERVOIR FOR VARIOUS METHODS OF OPERATION FOR THE PERIOD 1914-15 THROUGH 1956-57 (continued)

Ġ	safe yield operation of Hodges Secondary yield operation of Hodges Secondary yield operation of Hodges Sheservoir with secondary yield secondary yield the secondary yield sherland Reservoirs superation of Sutherland Reservoir	:Average : Average : Average :Average : length of : storage : surface :length of reshore line : for sea- : area for :shore line : for season; son, in : season, :for season, son in miles : acre-feet : in acres :in miles	720 15 25,800 1,010 18 2,900 210 7 660 14 23,800 960 17 3,000 220 7 1,080 19 30,700 1,160 20 22,800 930 17 1,160 20 31,800 1,190 20 27,900 1,080 19 1,160 20 31,800 1,190 20 28,300 1,100 19	1,120 19 31,100 1,180 20 21,400 880 17 1,190 20 32,300 1,210 21 27,400 1,070 19 1,200 20 32,400 1,210 21 30,200 1,150 20 1,160 20 31,400 1,190 20 27,000 1,060 19 1,150 20 31,200 1,180 20 20,600 850 16	1,140 20 31,100 1,180 20 11,200 480 11 1,160 20 31,700 1,190 20 3,900 250 8 930 17 27,600 1,080 19 2,800 210 7 610 13 22,600 920 17 2,500 190 7
36-11-2	Method Combined safe yield operation of Hodges and Sutherland Reservoirs	Average surface area for season, in acres			
	Combined sa Hodges and	Average storage for sea- son, in	17,700 114,900 27,600 30,700	29,300 31,600 30,600	29,600 30,600 23,000
		Season	1934-35 -36 -37 -38 -39	1939-40 -41 -42 -43 -44 -41	1944-45 -46 -47 -48

SUMMARY OF SEASONAL STORAGE, SURFACE AREA, AND LENGTH OF SHORE LINE OF HODGES RESERVOIR FOR VARIOUS METHODS OF OPERATION FOR THE PERIOD 1914-15 THROUGH 1956-57 (continued)

90	Combined s Hodges and	Season : Average : storage : for sea- : son, in : acre-feet	1949-50 3,000 -51 3,000 -52 10,300 -53 8,200 -54 4,000	1954-55 3,200 -56 3,000 -57 3,000	3-year average 21,500
	afe yield o Sutherland	Average surface area for season, in acres	220 220 500 110 250	230 220 220	860
Method	Combined safe yield operation of Hodges and Sutherland Reservoirs	:Average :length of :shore line :for season,	7 11 10 8	2 2 2	16
	: Safe yield : Reservoir : operation	: Average : storage : for sea- ; son, in	13,800 9,900 15,600 14,900	12,600 8,900 5,700	25,600
of	Safe yield operation of Hodges Reservoir with secondary yield operation of Sutherland Reserv	* Average surface area for season, in acres	660 480 690 730 700	580 440 320	1,000
	Safe yield operation of Hodges Reservoir with secondary yield operation of Sutherland Reservoir	:Average : :length of : :shore line : :for season,: :in miles :	ដូចក្នុង	دا 19	18
operation		<pre>: Average : storage : for sea- ; son, in : acre-feet</pre>	2,000 1,600 5,700 2,900 3,100	2,900 2,500 2,100	12,700
	Secondary yield operation of Hodg Reservoir with secondary yield operation of Sutherland Reservoir	: Average : surface : area for : season,	170 140 320 210 220	210 190 180	260
	Secondary yield operation of Hodges Reservoir with secondary yield operation of Sutherland Reservoir	:Average :length of :shore line :for season,	77266	C C 9	12

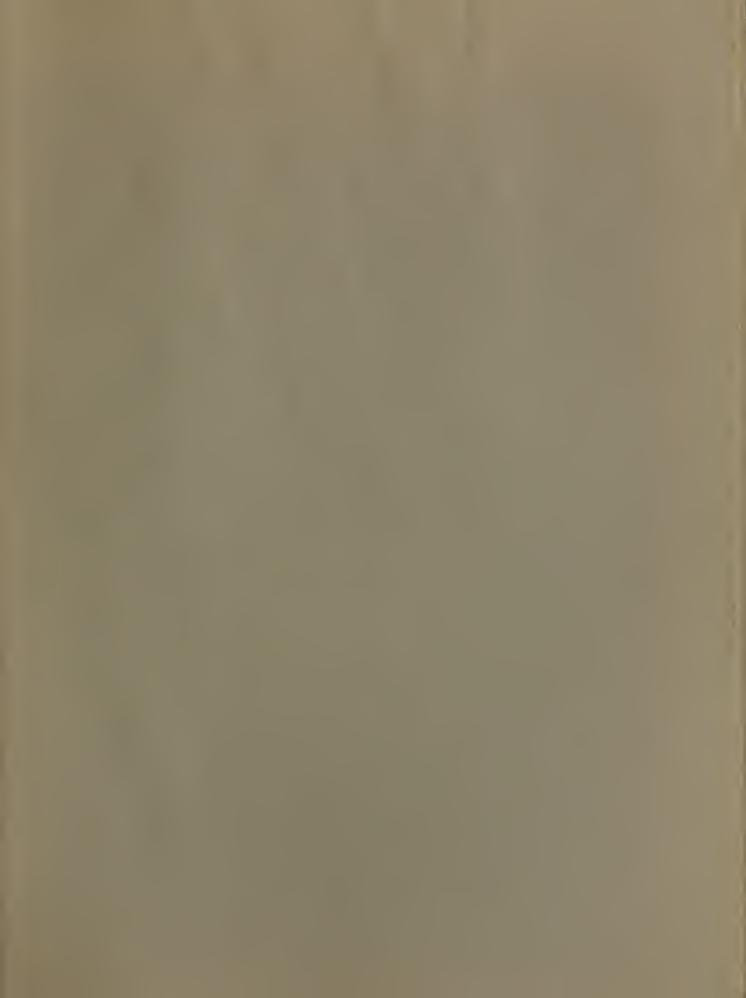












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